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**Evening Meeting.**

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Monday, May 25th, 1868.

W. STIRLING LACON, Esq., in the Chair.

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NAMES of MEMBERS who joined the Institution between the 18th and 25th of May, 1868.

LIFE.

Hay, James Francis Dalrymple, Lieut. Royal Ayrshire and Galloway Mil. 6*l.*  
Scott, William, Lieut. R.A. 9*l.*

ANNUAL.

Pym, Samuel, Lieut. R.A. 1 <i>l.</i>	Lennox, Lord A. C. Gordon, Lieut. Gren.
Stevenson, R. A., Captain R.A. 1 <i>l.</i>	Guards. 1 <i>l.</i>
Wickham, John, Capt. Hants Mil. 1 <i>l.</i>	Hardy, Chas. G., Lieut. Gren. Gds. 1 <i>l.</i>

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**CIRCULAR SHIPS OF WAR WITH IMMERSED MOTIVE POWER.**

By JOHN ELDER, Esq.

In adopting the title selected for the paper I am about to read to this meeting, I think it right to premise, that whilst some results of recent experiments made by me are of considerable interest to the naval architect and to others engaged in those branches of scientific investigation and practice into which enter the consideration of the values of forms and the different properties of solid bodies designed for floating in and being propelled through fluids, and are, I think, likely to prove of sufficient interest to merit special consideration, they could not be properly treated of in the present paper. I hope, however, to be permitted during the early part of the next session of the Royal United

Service Institution, to lay before you, in the form of completed and well digested results, what I believe will prove of interest to the members of this important scientific Institution, and to scientific and practical men generally; when probably they may assist to make clear much that has hitherto been but imperfectly understood in connection with the development of the "theory of the forms of least resistance," the resistance of bodies passing through "fluids," and other subjects under which such matters have been treated of by the various theoretical writers and scientific experimentalists who have flourished during the last and present centuries. On the one hand, I do not pretend that any great discoveries have been made by me in connection with the investigation of the present subject, or that I am going to revolutionize the whole practice of naval construction, and demolish the entire fabric upon which the construction of ships and the education of their builders have hitherto been based. It must, however, be clear to the minds of every one present, that naval construction is now in a state of transition; that much that has been done upon which the national wealth of this country has been enormously lavished with most unsatisfactory results, is entirely due to a want of that exact knowledge which belongs to other branches of science, and which should (and might) guide the professors of naval architecture in their teachings. It is to be hoped that ere long, practical men will be so well instructed by these professors that they may be able to follow their legitimate avocation of constructing and manufacturing for profit, without engaging in direct or indirect conflicts with natural laws, or producing unsatisfactory and undesired results, which needed not the surroundings of scientific theories for their production, but might have been equally well obtained by the old practice of the "rule of thumb."

I think it also right to premise, that the occasion and the shortness of the time at our disposal induce me to believe that the opportunity now afforded will be best availed of, and employed most to the satisfaction of my hearers, if I avoid all scientific speculation, and theorising; I will therefore confine myself to the briefest explanation of the subject of the present paper, and to describing the various illustrative diagrams, &c., suspended on the walls, leaving the more time for that which to my mind is the most valuable and useful result of such meetings as these, viz., the discussion which is evoked by the reading of papers. I wish to do this especially this evening, as I am favoured with so distinguished an audience, amongst whom I perceive many gentlemen of the highest eminence connected with the several branches of "*l'art naval*," the Commanders of our ships of war, the designers and constructors of the fleets of the past and present, and some who claim to be scientific designers of the "fleets of the future." I will therefore at once proceed to describe my "circular ships of war with immersed motive power," confining myself as closely as possible thereto, and avoiding the use, as far as possible, of all technicalities—as well as of scientific terms, speculations and theories—leaving, no doubt, much unsaid in the course of the reading of the paper, but the more to be evoked and eliminated during the discussion which I trust will follow.

*Circular Ships.*

I do not in this paper propose to enter upon the question of the suitability of circular ships as sea-going, passenger, and freight-carrying vessels, but intend to limit myself to their applicability for sea-going ships for coast and harbour defence, and may also, if time permit, point out their superiority, general usefulness, and infinitely smaller cost as compared with stone forts constructed in estuaries, channels, and rivers as most important national questions; also their capability as floating platforms for fighting guns of the largest possible calibre with the advantage due to the greater stability and steadiness thus attainable, and their suitability for carrying monster mortars, permitting of the discharge therefrom of shells of greater size, and containing larger explosive charges than heretofore, and with an accuracy never hitherto obtainable in firing from a mortar ship. Beyond, or in addition to these comparisons with existing ships or vessels of war, and with fixed or built forts, I propose briefly to call attention to what for the first time has been possible in connection with naval attack, and which is essentially novel and peculiar to this form of vessel—the peculiar manœuvring powers of which they are capable, and the formidable character of such vessels when so used or employed against an enemy's fleet. I am aware that circular structures have heretofore been projected or proposed as floating buoys and beacons, such as those of the late Mr. Herbert, the late Mr. George Rennie, and Mr. Oldham, of Hull, and all the floating lights, beacons, batteries, and other vessels of Mr. John Moody, of Goole, which are not circular, either on the plane or in the vertical section, but, as described by Mr. Moody, in the specification of his patent, are "of starlike form, with four or other number of arms," and he adds, they are to be made "with a flat bottom, and over it is a deck, arched in all directions." Of course any of these last described structures might be fitted with steam power, but it is self-evident that neither of them are designed to be used or employed as steam propelled ships of war for naval attack, nor are they capable of being moved but at very low speeds with the expenditure of great power.

*Circular Ships intended for the purpose of Naval Defence and Attack.*

I believe it has been generally conceded by the highest professional authorities amongst the commanders and fighters of our naval ships, that the turret or circular, or "all round" system is the handiest and best, the handiest for working heavy guns, and the best form for resisting shot. The question naturally suggests itself what is the best form of vessel in which a turret may be carried?

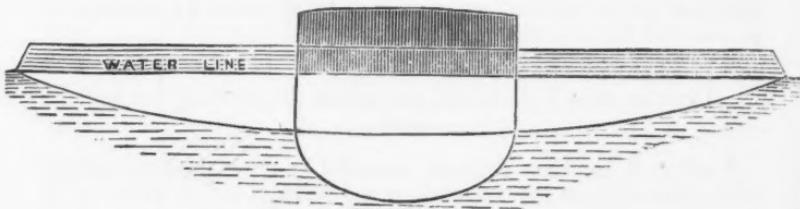
Whilst studying the questions of turret-carrying and gun-fighting, it occurred to me that there still remained another mode of dealing with these questions, namely, that of making the turret carry itself, as it were, or in other words, to make a vessel perfectly circular on the plane and the vertical section representing a small portion of a circle, and the

frame lines of which should all radiate from a common centre, so that any section taken across the diameter would be similar to any other section taken on any other line passing through the common centre, or to use a familiar illustration, to make the shape of the hull of the vessel like a slice cut straight off an orange, the skin representing the skin of the vessel. See Plates xxiv and xxv.

By so constructing a vessel it would be able not only to travel in a straight line in any given direction, whether forward, backward, or angular, but it would also be able to revolve with great facility while so moving or when stationary, but without the use of revolving gear or mechanical apparatus liable to the contingency of becoming jammed; and the turret also might be enormously increased in size, and be capable of carrying a proportionately larger number of guns and mortars of colossal dimensions with perfect safety.

After making some experiments on the resistance offered by various circular forms of vessels in passing through water, I found that the immersed portion of a vessel having for its outline a small segment of a large sphere, so that the vertical or buttock lines were very fine, required no more power than would have to be exerted in order to make an ordinary iron-clad vessel of war, of the same displacement, travel, or move through the water at the same speed. Thus, upon making two models, one of the ordinary form, and one of a circular vessel of equal displacement, and towing them at the same speed through the water by means of a line, having a scale-beam or yoke, interposed, the tractive force upon each tow line attached to each end of the scale beam, being the same, I found that the yoke (or scale beam) interposed between the towing boat and the vessel being towed, was constantly at right angles to the line of forward motion, so that the resistance offered by each vessel was practically the same in each case.

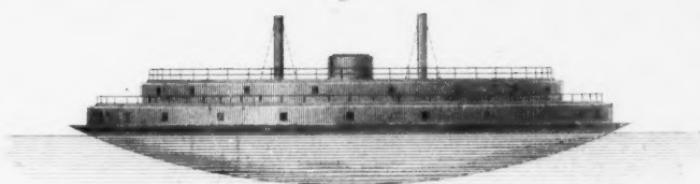
This result will be readily apprehended or understood when it is shown by the accompanying diagram illustrative of the two cross sections,



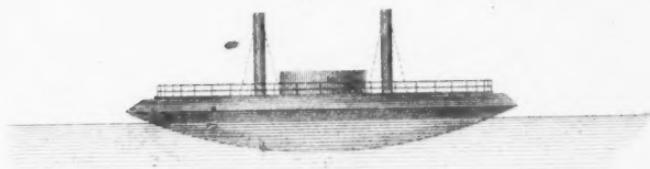
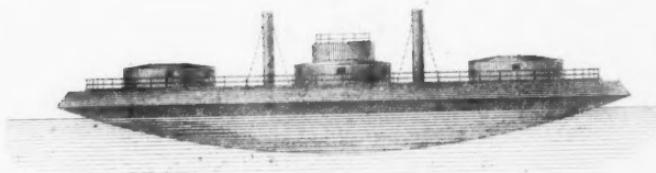
that the circular model has a much lighter draught than the other, in fact the circular model drew a little less than one-half the depth of water, whilst the breadth of the section is greatly increased, as will be hereafter referred to and explained more in detail.

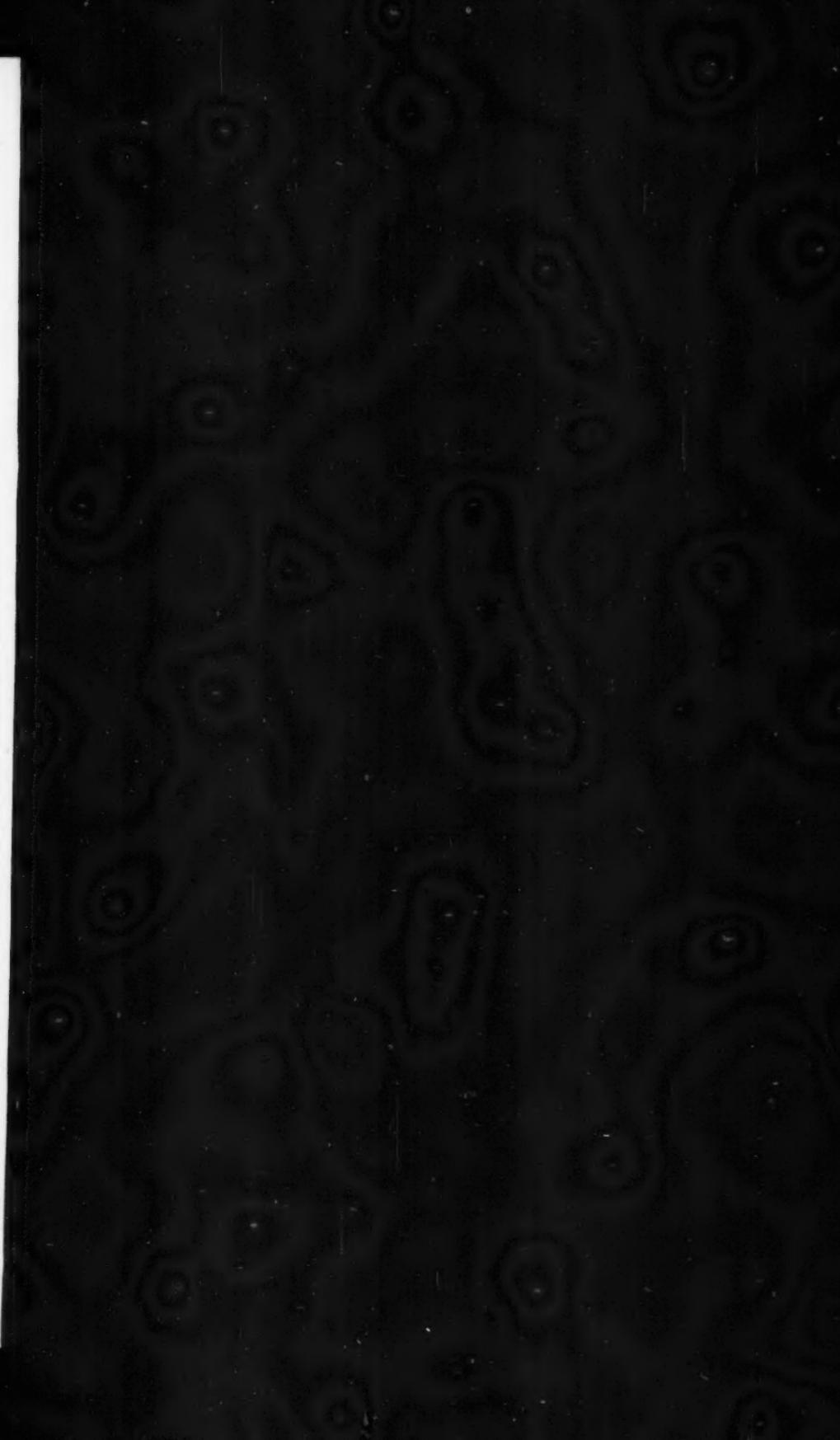
I may here observe in a general way, that these experiments have thus far proved what might not perhaps have been expected, that there is no reason why a vessel of the same displacement, as one of

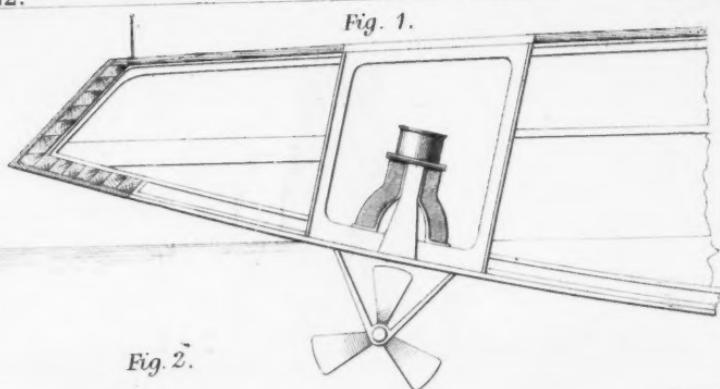
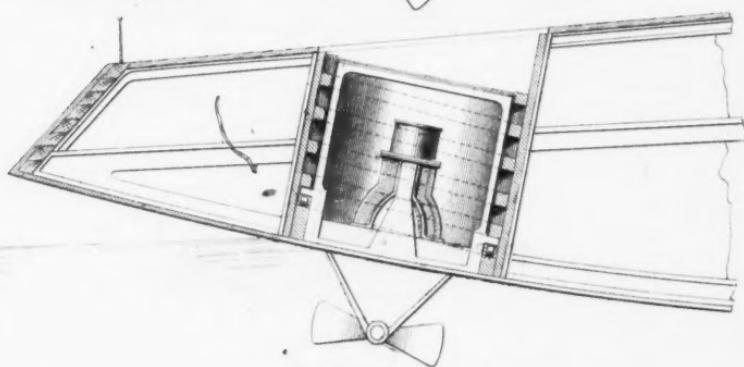
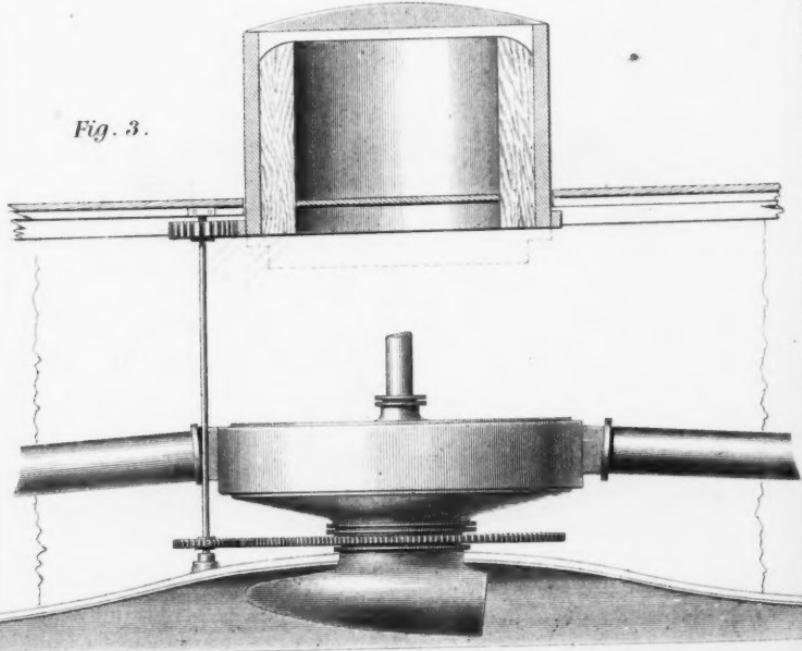


*Fig. 1.**Fig. 2.**Fig. 3.**Fig. 4.*

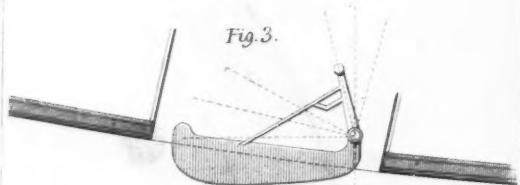
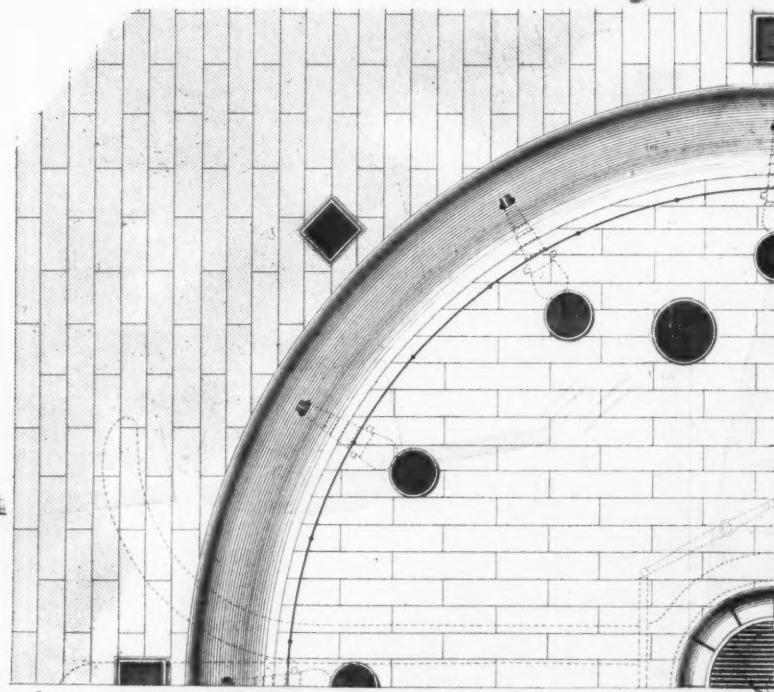
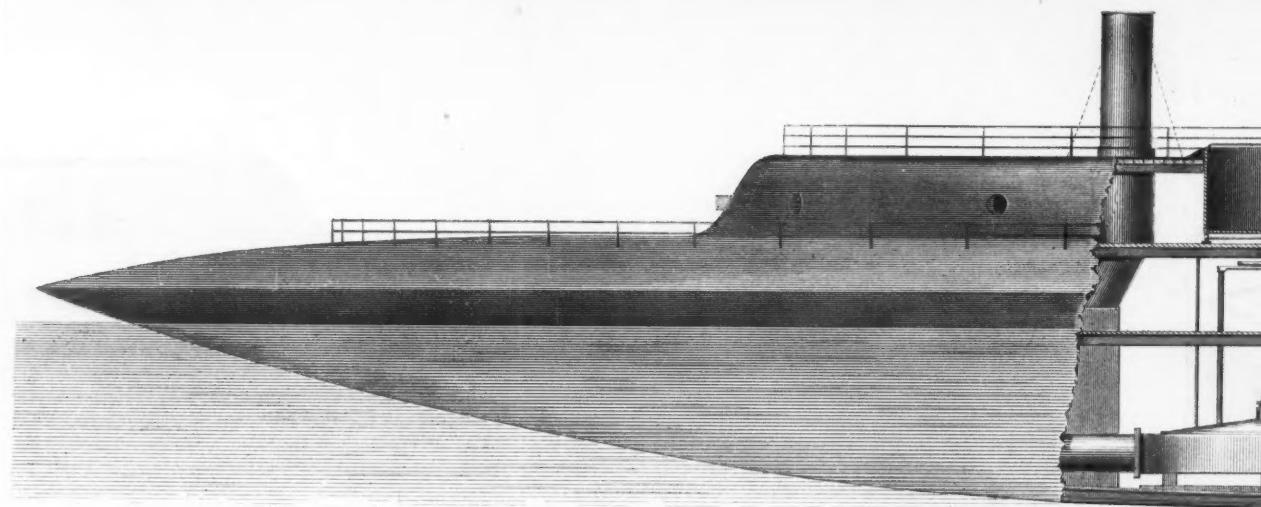


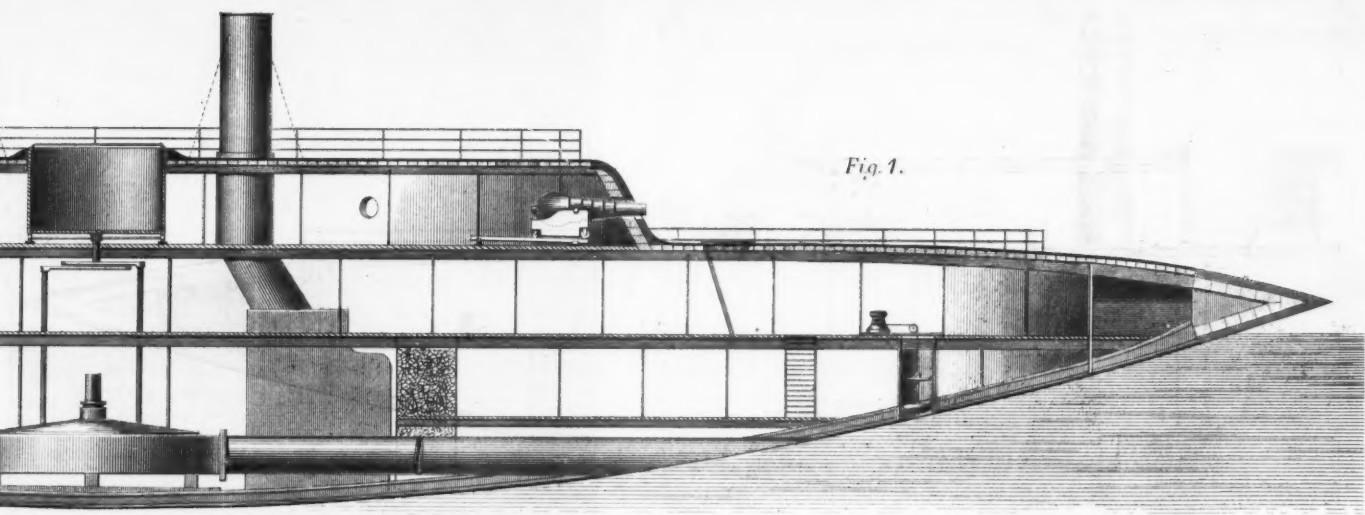
*Fig. 1.**Fig. 2.**Fig. 3.**Fig. 4.*



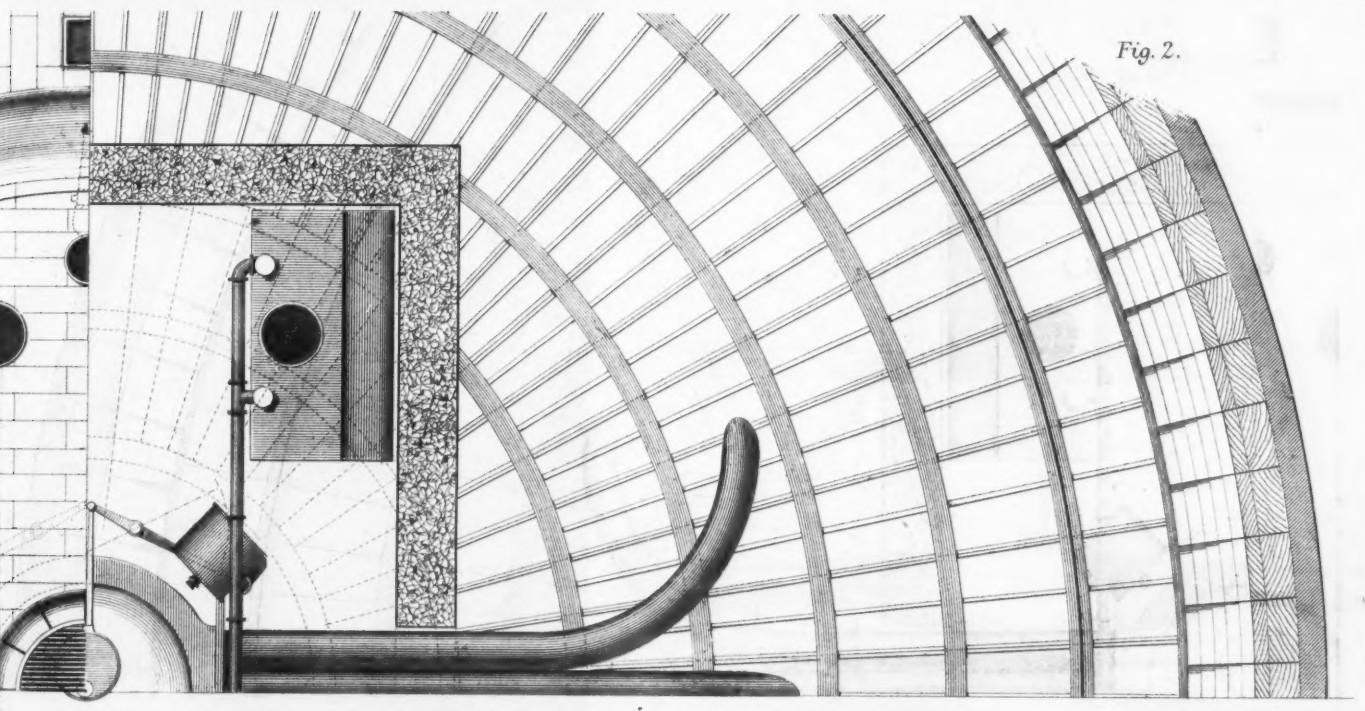
*Fig. 1.**Fig. 2.**Fig. 3.*







*Fig. 1.*



*Fig. 2.*



our best iron-clads, but circular in form, may not be propelled at an equally high rate of speed, whilst from the very light draught of the circular ship, it would be able to approach and enter many places at present quite inaccessible to our large vessels as at present constructed.

I also found, as might perhaps have been expected, that the circular model was much drier and a better sea boat in rough weather than the ordinary model, and its immense superiority as regards stability is sufficiently obvious to render unnecessary any remarks upon that branch of this subject.

To illustrate the modes of propelling, I have shown in one of the diagrams (Plate xxvi) several ways that might be employed, such as fitting one or more screw propellers supported by brackets (Figs. 1 and 2), fixed to the outer skin of the vessel. Another method might be adopted in which a casing or trunk is formed, so as to admit the crank shaft, and the screw shaft being carried sufficiently low down, as to enable the propeller to work in unbroken water. I have also shown a plan with a water jet propeller (Fig. 3).

The circular vessel from its form, and the very nature of its construction presents an admirable opportunity for placing in the most secure position the machinery and apparatus necessary for transmitting and communicating motion to the propeller, as well as for controlling and manoeuvring the vessel whilst in motion, it also offers peculiar advantages for adapting the turbine or emissive jet propeller over any other form of vessel heretofore designed.

I therefore proceeded to arrange and adapt the hydraulic propelling apparatus to my own requirements, and as it will be seen on reference to the drawings (Plate xxvii, figs. 1 and 2), nothing can be more compact and convenient than this adaptation. By this means the contour of the vessel may be preserved unaltered, and it is consequently perfectly free to travel in any direction, or to revolve fly-wheel-like with the smallest possible expenditure of power, there being no projecting parts or pieces either of machinery, gearing, or casings to impede the vessel's movement.

In order that the efficiency of the vessel as a war-ship should be fully developed, it is necessary that it should be capable of manoeuvring with the utmost possible rapidity, or that it should be capable of having the direction of its motion or movement changed from right to left, or reversed, or be capable of revolving or pivoting without difficulty or loss of time. In our long build of broadside-battery ships of war, to turn about after firing one broadside to discharge the other, is a matter involving an immense sweep in distance travelled, a vast expenditure of power, and a considerable loss of time, whereas, I fore-saw that I might accomplish the object so much desired by every naval tactician and artillerist, by bringing the whole of the guns under his command to bear upon the object of his attack with the greatest rapidity in any required order of succession, without any longitudinal or lateral—in fact without any linear-movement at all of the vessel or gun platform; this at the same time possessed a stability and steadiness which no existing form of floating battery or other ship of war can possibly possess.

Now, for the purpose of effecting the object sought to be attained, I designed the peculiar arrangement of machinery and apparatus which I have shown on an enlarged scale in a transverse vertical section and plan in Plate xxviii, figs. 1 and 2. Upon reference to these views, it will be seen that the machinery apparatus consists of a large turbine or horizontal centrifugal pump, the vertical axis of which is in the central line or axis of the circular ship, and the spindle, or driving shaft, forming the axis of the turbine or pump is rotated at the requisite or necessary speed by means of a steam-engine or engines in the usual way, and is capable of being set in motion, or it may be stopped readily either by the stopping of the engine, or by disconnection, or throwing out of gear by means of a clutch or other convenient apparatus.

For the purpose of causing the vessel to travel in a right line, or of changing its direction of motion at any angle from the line at which it was previously moving, and also for the purpose of giving a compound movement to the vessel whilst in motion, and also for the purpose of rotating the vessel about its own centre, either whilst the vessel has no forward or backward linear movement, and for producing a compound rotary and onward movement, I have contrived several simple and effective arrangements of propelling apparatus, some one or more of which, I propose to describe in connection with the employment of a turbine or centrifugal pump as before mentioned, and shown in Plates xxvii and xxix.

One of the arrangements which I have shown for effecting these various movements is, that in which the outer case or shell surrounding the turbine has four openings, and communication by means of large pipes between it and the water, in which the ship is floating. These pipes are placed at right angles to one another, and each pipe is increased near the turbine to double the area, and is divided horizontally by a web, as shown in the sectional view (Fig. 1, plate xxviii). At this point a valve is placed, and this valve is free to travel vertically, so that when lowered, it shuts the water off from the bottom division of the pipe, but leaves the upper division of the pipe open, and thus when it is raised, the lower division will be open, and the upper one closed, and when placed at half the length of its travel, it would shut off all communication between the turbine, and the external water, and so check the inflowing or outgoing, or admission or emission of the water.

The turbine itself is shown as similarly divided in two parts, my intention being that the lower half should be employed for a suction or indraught, and the other half for the delivery or emission. Now for the purpose of illustrating the action of this propelling apparatus, I will beg your attention for a few minutes to the several parts illustrated in Figs. 1 and 2, plate xxviii.

Now, supposing that the two cross pipes, C and D, are entirely closed, and that the valve in the pipe A is raised to its full extent, and the valve in the pipe B lowered, the turbine will have its lower half or suction open to the water through the pipe A, and its delivery or water jet similarly open through the pipe B, and consequently the



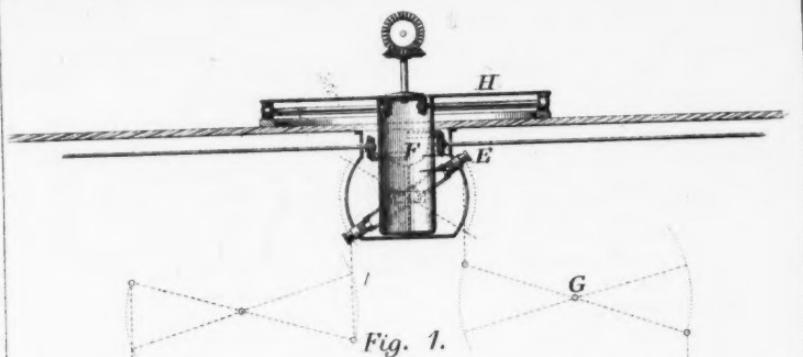


Fig. 1.

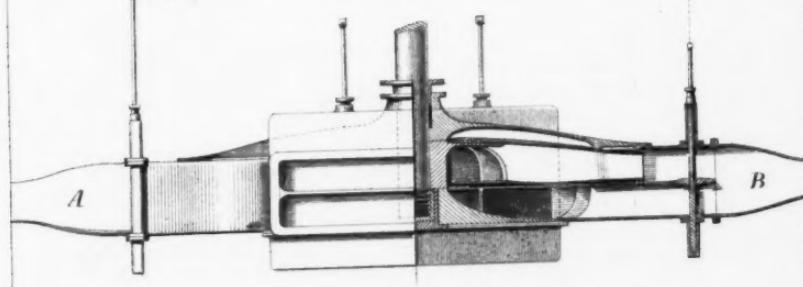
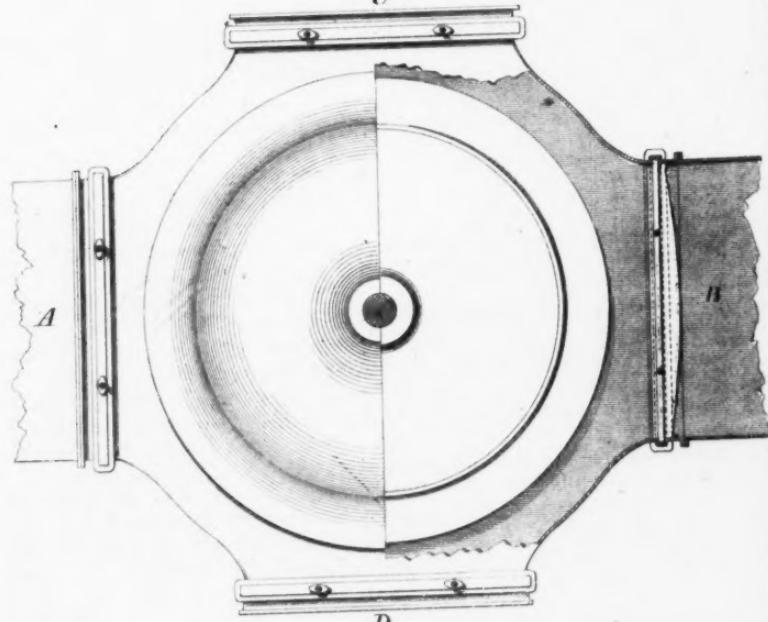
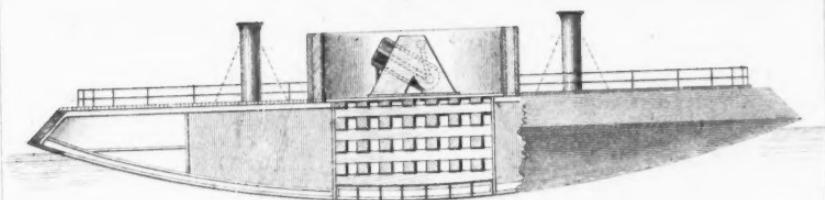
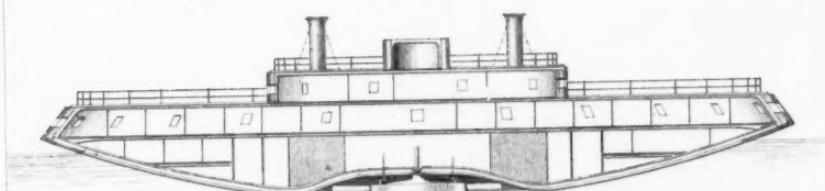
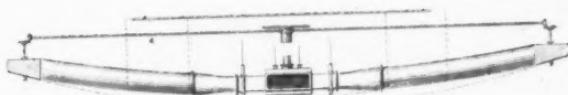
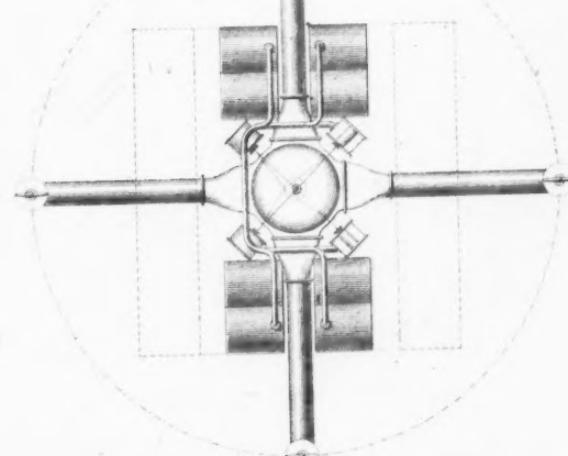


Fig. 2.





*Fig. 1.**Fig. 2.**Fig. 3.**Fig. 4.*

vessel would travel in the direction B A. If it were required suddenly to reverse the direction in which the vessel was travelling, it would only be necessary to lower the valve of the pipe A, and raise that in the pipe B. Again, by placing the valves of these two pipes A and B at half their stroke, all communication between the turbine, and the water would be closed, when by operating in a similar manner, as just described, the valves of the pipes C and D, a motion at right angles to the arrow in either direction would be at once obtained.

In order to actuate these several valves in connection with one another, they may be severally attached by means of suitable connecting rods and levers to a circular pulley or disk, E, Fig. 1, fixed at such an angle upon the drum, F, that the vertical distance of the highest to the lowest point is equal to the full travel of the valve, so that the valve B, that is attached to the highest point, is by means of the lever, G, placed in its lowest position, while the valve opposite to it, A, is placed in its highest position, the two other valves being both placed in their central position, of course entirely close the two cross pipes, C and D, and thus the vessel is now ready to travel in the direction B A.

Now, supposing the drum F is turned half way round, the valves of the pipe A will be brought to its lowest position, and the valve of the pipe B to its highest position, and consequently, as already described, the direction of the vessel will be reversed. In like manner, by turning the drum, F, a quarter of the way round only, the two other valves of the pipes, C and D, will be respectively at their highest and lowest positions, and the course of the vessel will be similarly varied. In order to vary the course of the ship in a slighter degree, or in other words, to steer it, balance-rudders (Figs. 3 and 4, plate xxix) are placed just at the end of the pipes and worked in the usual manner. A turntable, H (Plate xxviii), may be attached to the drum, F, and which will consequently revolve with it, so that a person standing upon this turntable with his back to the highest point of the angular pulley, and looking straight before him, will always be looking at the spot towards which the vessel is travelling, and thus by revolving the turntable and bringing himself when in that position to look at any particular spot in any direction, the vessel will travel towards it. By having a line drawn on the turntable, or by having a sight fixed in the proper line, the direction in which the vessel is travelling might be told at a glance, with the greatest precision. The whole of these valves may be worked by means of independent engines carried on the turntable itself, and the only manual power required would be to move a small handle, as from time to time may be necessary.

The vessel may be made to revolve by putting the rudders hard over, but if greater facility for revolving is required, curved pipes (Fig. 2, plate xxvii) would be used, in addition to the straight ones, already described, one being placed on either side of the straight pipe and the three being so worked by a valve that only one of them can be fully open at a time. It will thus be self-evident that if the water is taken through one of these curved pipes into the turbine, and delivered

by it through the opposite curved pipes, shown in dotted lines, so that the water travels somewhat in the form of the letter C, both the suction and delivery pipes are tending to force the vessel round. The vessel is thus enabled to travel in any direction, or to revolve by simply actuating the slide valves fitted to the respective pipes, and we have, therefore, a vessel capable of executing the most difficult manœuvres with the greatest rapidity. So much for the form of these vessels and for the mode in which I propose to move or actuate them.

*Armour-plating for Circular Ships.*

From the peculiar form of these vessels but little breadth of armour-plate will be required of any considerable thickness, as the whole of the lower part of the ship is inclined at such an acute angle with the horizon that it would be impossible to strike it injuriously except with a ricochet shot (see Plates xxiv and xxv).

*The Form of the Upper Portion of Circular Ships, whether employed for the purpose of Attack or Defence.*

The upper part of the vessel may be made of various forms (see Plates xxiv and xxv), thus the sides may be raised directly from the outer edge and sloped inwards so as to form a cutting edge round the rim of the vessel (Fig. 2, plate xxiv), and also be pierced for guns—a revolving pilot-house being placed in the centre from which the vessel is manœuvred, as before described, and as illustrated in Plate xxviii. The only heavy armour-plating required in this case is, as there shown, about 7 feet in breadth round the outside, and similar plating to protect the pilot-house.

Allowing the thickness of this armour-plating to be 8 inches on these parts and 3 inches on the lower angled portion for about 8 feet in width, the armour-plating would be about 2,000 tons in a vessel of 200 feet in diameter, with 13 feet draught of water, and capable of carrying 26 heavy guns.

As a modification of this plan, a second battery may be placed above this of smaller diameter, as shown in Fig. 1, plate xxiv, when the fighting power of the vessel would be increased by 10 guns, and the draught of water would then be about 14 feet. In Fig. 4, plate xxiv, is shown an elevation of another modification in the shape of the vessel. In this case there are no guns round the outer edge, but this part is made very sharp and immensely strong, and is meant to be used as a ram, or rather as a circular saw and ram combined. Thus, upon coming into collision with another vessel, a rotary motion may be imparted to it by forcing the water through the curved pipes, before described, which would then give the edge a combined ramming and cutting motion sufficient to make a very ugly gash in the side of the strongest iron-clad. The battery is intended to carry ten 300-pounder guns, and it is calculated that with proper appliances, a gun

of this size may be worked so as to fire once a minute; it would only be necessary to cause the vessel to revolve at that speed to deliver ten 300-pound shot against the same spot in the space of one minute. By having a "look-out" in the centre of this battery, with lines of sight accurately corresponding with the lines of fire of each gun, one man might, by means of lanyards, fire each gun as it came opposite the required spot, and thus the only training required to be done by hand would be for obtaining the required elevation.

Upon referring to the elevation, Fig. 4, plate xxiv, it will be seen that this vessel has the deck somewhat rounded, several advantages attaching to this form. In the first place it can be made very much stronger and better adapted for ramming purposes than is possible with a flush deck, the angle formed with the horizon by the plates above and below the cutting edge being about equal.

It would also be impossible to board a vessel with a rounded deck, while any water that might be shipped would immediately run off again.

In Plate xxvii, figs. 1 and 2, is shown a design for a still more powerful vessel, being 280 feet in diameter with 15 feet draught of water, and intended to carry 14 22½-ton guns, each throwing a 600-pound solid shot. In this case the vessel is intended to be manœuvred from a pilot-house above the battery, the arrangement for working the valves from it being shown in the drawing. Various other modifications, as shown in Plates xxiv and xxv, may be made, both in the external form or hull and also in the arrangement of the batteries. Thus the hull, instead of being a section of a sphere, may be in the shape of a truncated cone, which might in some cases be preferred. The vessel might also carry several tiers of guns and for some purposes, such as firing over the walls of a fort or high bank on shore, a turret or tower may be built to a considerable elevation (Fig. 1, plate xxv), the immense stability of this form easily admitting of such an arrangement.

The methods of propulsion, too, may be greatly varied; that shown in Fig. 2, plate xxix, being exceedingly simple. In this case the turbine is outside the vessel in a recess formed for the purpose. This turbine may be turned, by means of a rack and pinion, in any direction, while the same pinion-shaft carries at the other end a similar pinion-gearing into a similar rack attached to the pilot-house (see Fig. 3, plate xxvi), the turbine and pilot-house being turned simultaneously in the same direction. By placing an opening or look-out in the pilot-house, exactly over the suction of the turbine, the spot seen from thence, is the spot to which the vessel is travelling. Now, supposing the Officer in this pilot-house has the means, by the use of a small donkey-engine, or by any simple method, of turning it in any direction he pleases, he at the same time turns the turbine as well, and, therefore, by keeping any particular place in view through the opening in the pilot-house, the vessel will travel in that direction. He has therefore only to look at the object which he desires to approach, in order to enable the ship to be propelled directly to or towards it.

*The Construction and Method of Building the Circular Ships, and their General Arrangement.*

I propose next rapidly and cursorily to glance at these points, as the time allotted to me is now fast approaching its limit.

*Construction.*—The construction of these vessels is as simple as that of an ordinary iron ship, only that the frames and floors, instead of extending from keel to gunwale athwartship, radiate from the centre to gunwhale at the outer edge, every frame and floor being the same length and form (Figs. 1 and 2, plate xxx); this will greatly facilitate the erection of the structure.

These frames are thoroughly secured in their places by a series of circular keelsons or stringers, placed as deemed necessary. Beams may either be put in straight across (Fig. 1), or to radiate (Fig. 2) (the straight being preferred); the beams on one deck being placed at right angles to those above or below. The beams will be made in straight lengths of about 40 to 50 feet, secured with a long scarf plate, and thoroughly supported by a series of holds. The outside plating will be easily put on, as each strake of plates will have exactly the same "set and say." In some cases it may be preferred, instead of radial framing to frame the vessel with a series of circular keelsons or frames, and the stringers to radiate as the frames do in the first method described; this would answer every purpose just as well, but would be more difficult and expensive to erect.

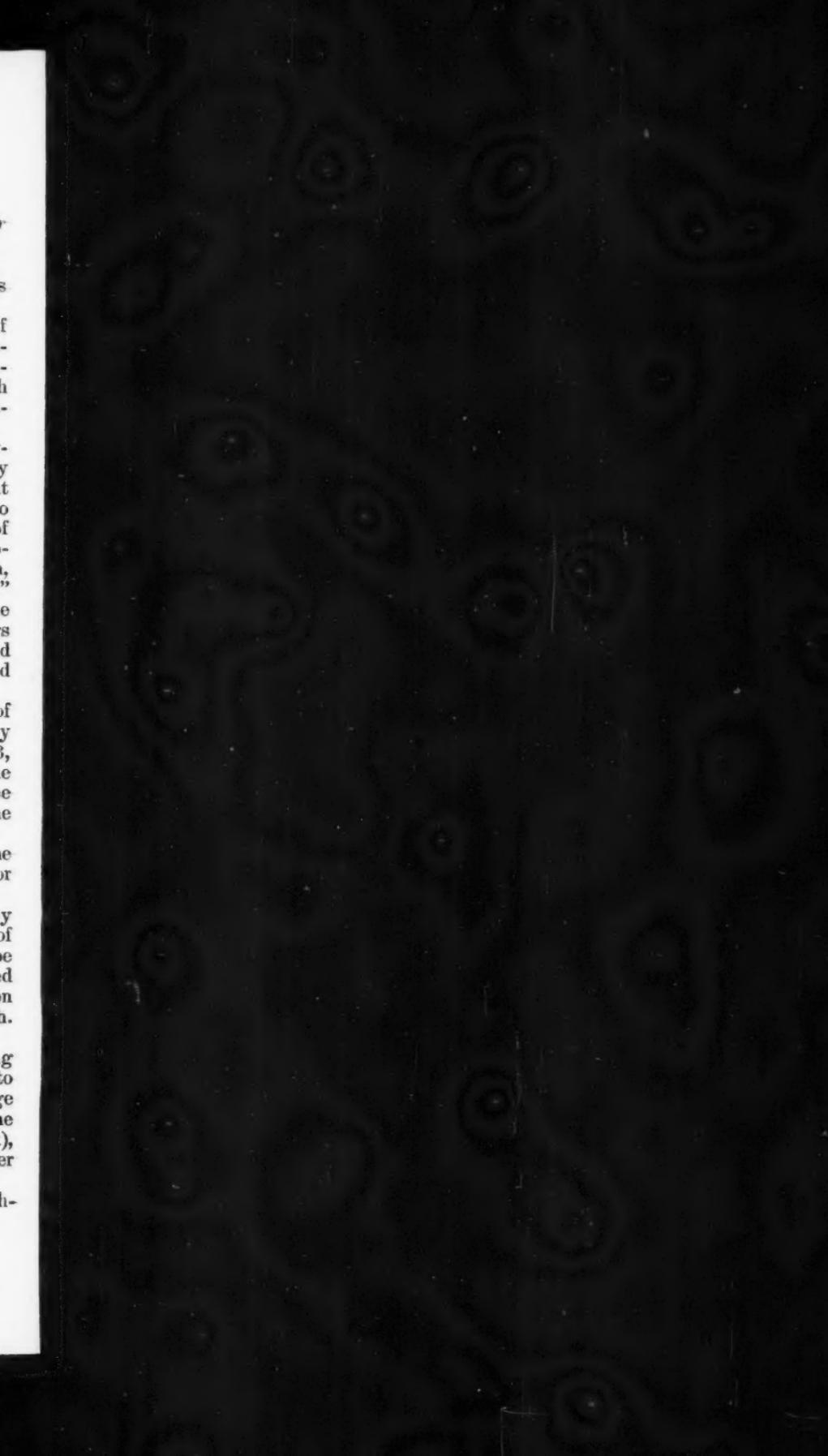
*Steering.*—It is proposed to steer these vessels, either by means of ordinary rudders placed at the outlet of the propelling pipes, or by blade rudders similar to those used in the Indus flotilla boats (Fig. 3, plate xxvii), placed at an angle of  $42^{\circ}$ , fitted in water-tight wells, the one being lowered as the other is raised. Four such rudders would be sufficient for a vessel of this class, and all would be worked by one steering gear.

*Bulkheads.*—These may be placed in any position, and divide the vessel into as many compartments as may be thought necessary for safety.

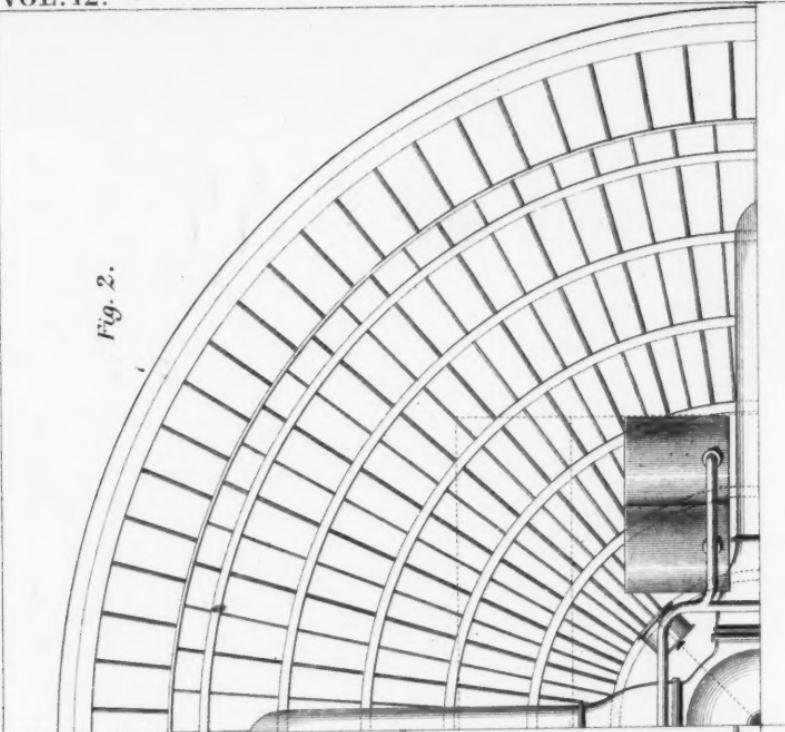
*Ventilation.*—This is to be obtained by means of fans worked by donkey-engines, it not being desirable to have as great a number of skylights and hatches as in ordinary ships, and all openings should be made as conveniently small as possible, and fitted with armoured hatches of the same strength as the deck covering, so that when going into action, all exposed parts shall be of the same relative strength. A ventilator is fitted in the battery deck over each gun.

*Mortar Beds.*—These vessels are admirably adapted for carrying large mortars, on account of their great stability, and it is proposed to use them for such purposes by forming the mortar bed of a large area, and constructing the same of baulks of timber laid one on the other after the manner of a steam-hammer bed (Fig. 1, plate xxix), the upper portion of the bed may be fitted with a series of india-rubber buffers, or springs to assist in deadening the recoil.

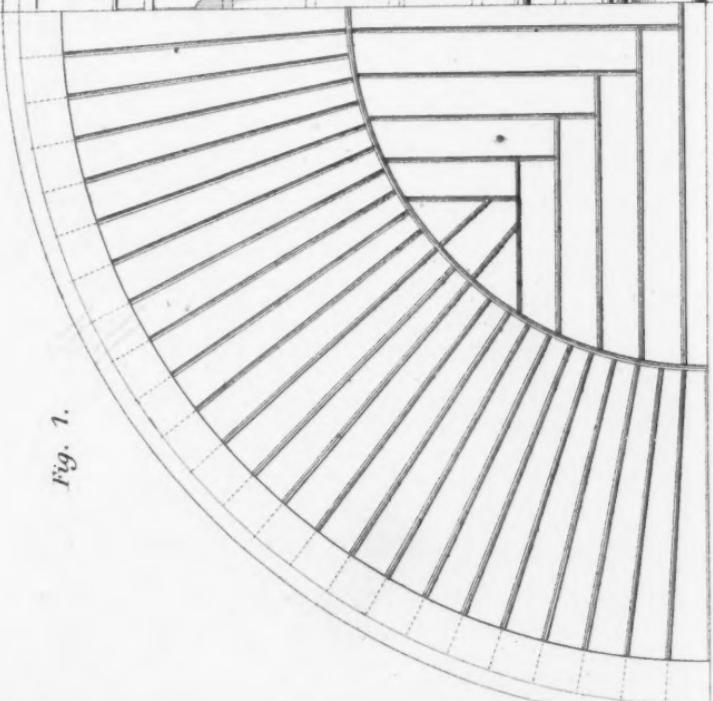
*Mooring.*—It is proposed to moor these vessels by means of mush-



*Fig. 2.*



*Fig. 1.*



room or other approved form of anchors, worked by capstans, &c., in the usual manner, but instead of hawsepipes, catheads, &c., we lower the anchors through a well in the ship's bottom (Fig. 1, plate xxvii), and when the anchor is raised, the lower portion of it is flush with the outside plating of the vessel. The well is constructed of a sufficient size, and sufficiently high out of the water to introduce another anchor in the event of losing one.

*Turrets.*—For the turning gear, the plan usually in practice is proposed to be employed, but the principal object of fitting turrets to these vessels is for fighting the heaviest class of guns when the ship is at anchor, and the whole structure cannot revolve in the water as one turret afloat, until steam is got up. Another advantage is, that we may have these turrets higher out of the water than in ordinary Monitors, and so fire down on the decks of such vessels; but in some cases for harbour defence, we would propose low vessels carrying say four or more turrets as the case might be. In such a class, would be combined all the advantages of a "Monitor," and if need be a most formidable ram when underweigh.

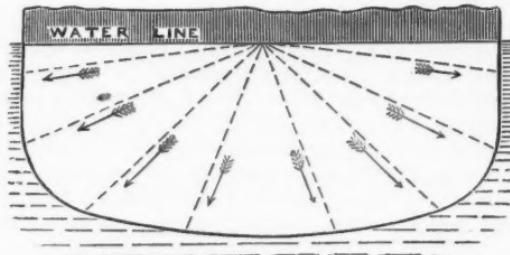
*Ram.*—Any portion of the armoured edge will act as a ram, and if the vessel is driven at any floating body, before coming in contact with the same, it is proposed by means of its peculiar machinery to cause the whole structure to revolve, which will deaden the shock on the circular vessel to a considerable extent, and enable it to act as a saw against the sides of its opponent, thus doing enormous damage.

*Accommodation and Stowage.*—Space for fuel is provided all round the central portion of the vessel occupied by the machinery and boilers, and may be of any capacity that is desired. Alongside of the coal-bunkers, so as to be directly under the battery, may be fitted either two or four magazines and shell-rooms, as may be necessary; these having water tanks on the top, and around three sides, with the bunkers on the fourth, will be secure in case of fire, and pipes may be fitted for flooding the same without injury to any other portion of the holds. I have shown in Figs. 1 and 2, plate xxvii, that the main-deck is divided into four segments by strong iron, water-tight bulkheads, and a circular collision bulkhead extending all round about 12 feet from the periphery. On this deck is provided ample accommodation for the Officers, crew, engineers, Marines, &c., in fact from the form of vessel, the amount of space for accommodation is more than will be required. Below are the holds fitted in the usual manner, with store-rooms, bread-rooms, chain lockers, boatswain's and gunner's stores, and all the usual appurtenances of a vessel of war.

*Battery.*—Access is obtained to the battery from the deck below, and from its circular form great space and convenience is secured for working a heavier class of guns, and ample room is provided for the cranes, and all the usual gear and machinery for hoisting up heavy shot and shell.

*Speed and Resistance.*—As I have before stated, a circular vessel of any of the accompanying forms will offer but little, if any, more resistance to the water than vessels of the "Minotaur" and "Agin-court" class. The breadth on the water-line amidships for a vessel of

200 feet extreme diameter, we will take at an average to be 185 feet, with a draught of water in the centre of 14 feet, a displacement of about 7,000 tons, and an immersed area in square feet of about 2,100 feet. Our larger iron-clads—say the "Warrior"—are about 58 feet beam, drawing somewhere about 30 feet of water, which will give an immersed area, allowing for rise of floor and turn of bilges of about 1,500 square feet. Now, as far as this appears at first sight, the difference in area of midship section is greatly in favour of the "Minotaur" class; but at the same time, it must be borne in mind that the draught of water is more than doubled, and for every foot of immersion, the resistance to a moving body is immensely increased. Another matter to be duly considered, and a very important one, is, that all vessels only divide the water in accordance with the form of their water-lines, on and a little below the surface, and on their flat sides amidships, if flat-sided (this vessel has no flat side), from whence the water is displaced or driven under, as shown in the sketch. This



may be proved by examining a steam-yacht's bottom that has been newly black-leaded or painted, and not allowed to dry before making a run, when a number of wavy marks will be found in the direction I have named. Another instance in proof thereof is the swim of the ordinary Thames barge; the longer and easier "the swim," both fore



and aft, the easier is the barge in tow, or the faster will she sail. And I may mention, as a still further proof of this theory with regard to fine vertical sections, as influencing the speed and resistance of vessels, the fact, that when a well formed steamer gets underway, as she attains her speed so she lifts her bow out of the water to a

certain extent, and the old bluff-bowed vessel, or the vessel with fine water-lines and bluff forward buttocks (and there are many such), and with the vertical sections or buttocks much finer aft than forward, has the tendency to immerse her bow, instead of to rise, consequently proving that for speed, fine fore and aft buttock-lines are of the utmost importance when combined with the least possible depth of immersion. For example, the old "America" yacht, of A.D. 1851, had the finest fore and aft buttocks or vertical sections of any vessel afloat, good beam and light draught; consequently to these qualities is attributable her great speed. Now, with regard to the circular form of ships, it is evident that they have the finest possible vertical sections that can be obtained in any vessel, and putting these facts to weigh with shallow draught against the extra amount of area of immersed section and the fulness of the water-lines, it is evident that the increase of resistance is but of little or no importance, for it will be seen by reference to the first woodcut, that whilst in the circular ship the relation of breadth to depth of immersed sectional area is as 185 to 14, giving 2,100 feet, a ship of the ordinary form of the "Minotaur" class would have a breadth of 59 feet and a depth of 30 feet, giving nearly 1,500 feet.

I have now occupied more time than I intended to devote to the reading of this paper, but I trust that this will not militate against the fullest discussion of the subject, which I now respectfully invite; and in conclusion, I shall be happy to answer any questions arising out of its reading, and which are in my power to reply to. If I am fortunate enough to have succeeded in occupying your time without wearying you with so unpopular a subject, I shall at least have done as much as many other abler men have done when they have undertaken the task of inviting public attention to a subject, the ultimate importance of which may not have been understood, and must not be measured by the unpreparedness of the public mind; and on any question which involves the judicious and useful expenditure of money for a specific and well defined purpose as against the lavish and injudicious outlay of money raised by national taxation in a time of national disaster and depression, such a subject as the present, although presented in so unscientific and popular a manner to so distinguished an audience, still merits for itself a share of public attention.

The CHAIRMAN : You have heard the invitation of Mr. Elder, and the hope he has expressed that the value of his paper may be brought out by the discussion that will follow. If any gentleman has any observations to make we shall be very happy to hear them, but I would suggest that any gentleman who addresses us should keep his remarks entirely to the subject before the meeting, and, in order that others may have the opportunity of taking part in the discussion, that he should confine himself to ten minutes. If any one has any questions to ask, Mr. Elder will be kind enough to make a note of them, and at the end of the discussion answer them in gross.

Admiral HALSTED : If you will permit me to say, just to break the ground for a very old friend of mine, for whom I have great esteem, that he must not be surprised if he has taken us all aback, when we have got to consider so utter and entire a novelty as that which he has brought before us.

Captain J. H. I. ALEXANDER, R.N. : I wish to ask what is the proposed manner of heaving the anchor up, for I see in one of the sectional plans the capstan on the

upper deck, which seems to me excessively exposed? not that I can see any difficulty in placing it below the water line, on the next deck. I would also ask what is the proposed thickness of the defence of the upper deck against a vessel high enough in the water to fire down on her? It seems to me that there is a very large space exposed there, and if it is proposed to give a very great thickness, of course it will add very greatly to the draught and tonnage of the vessel. Otherwise, while confessing that, like the gentleman behind me, I am rather taken aback, still I am very much in favour of the plan. It seems to me that, if it were possible to adopt the tortoise-shell form for the upper portion of the ship at an angle which would in all probability glance a shot off, it would be much more secure, and would be equally available for the purpose required.

Mr. ELDER: That is about the angle (showing the model).

Captain ALEXANDER: Even that model which you have there seems to me to be a very insufficient angle for deflecting shot.

Vice-Admiral ROBINSON, Controller of the Navy: The few observations that I was going to make are rather met by the observations that we have heard from the gallant Officer—that the plan before us is a matter of extreme novelty, and that we are rather taken aback by such a novelty. I confess that, having for a great many years of my life, in an official capacity, been dealing with novelties every day, and having been instrumental in advancing some novelties, not exactly towards perfection, but at any rate I hope in the direction of progress, I do not feel absolutely taken aback by the very novel proposition that you, Mr. Elder, have introduced, with great ability, to the meeting this night. I think, on the contrary, it is a proposal that we ought to consider most attentively, and we shall be glad to hear from you answers, which I have no doubt you are perfectly capable of giving, to many objections that must at once suggest themselves; I am sure they suggested themselves to your mind when you were contriving and inventing this machine or ship. The obvious difficulties and objections that must present themselves to any one like yourself, or like most of the gentlemen in this room conversant with the motion of bodies through the water, are in connection with that extraordinary midship section that you have got to deal with. I see before me a midship section, in a ship 300 feet long, I ought rather to say a circular vessel 300 feet in diameter, which midship section cannot be much less than 280 feet across at the water line. One of the ablest naval architects in Great Britain, to whom we all bow, who never speaks or never writes upon any subject without both enlightening and delighting us, Mr. Scott Russell, has said of a midship section, “the midship section of a ship is the thing that you have to drive.” Now, I own, and I am sure you did when you first began to think and to consider this important subject, that I look with a little stupefaction at a midship section at the water line, which presents a breadth of something like 280 feet, to be pushed through the water at any velocity whatever. I observed you fell into a mistake of no very great moment, it does not affect your argument, in supposing that the “Minotaur” class draw 30 feet of water; the “Minotaur” class only draw 26 feet of water. Still the excess of draught of water in the “Minotaur” over the circular ship I do not deny is very great, but the immersed midship section of the “Minotaur” class has never at the load line exceeded 1,220 feet—something like that, not 1,500 feet as you suppose. Now I want to know, and I am sure you must have thought of it, and must be able to inform the meeting, and will do so hereafter, how you are going to drive a midship section that has 280 feet width through the water, when a midship section that is 60 feet wide presents such enormous difficulties that engines of 6,000 and 7,000 horse-power are required to drive it? That is one of the first difficulties that presents itself to my mind, but one which I have no doubt you are competent to remove. Another difficulty which presents itself is, with reference to the steering blades or rudders with which you intend to direct the course of your vessel, if I do not misunderstand you, if I do, you will set me right. I am perfectly well aware how you will perform your twirling operations and your little sawing with your machine when you get alongside your enemy, by means of hydraulic power, emitting water on the different sides of your engine by your hydraulic apparatus. But what I do not understand is, how upon a given course, with the sea and wind in a given direction, you will with your

steering-blades and rudder compel a circular machine like that to go on a given and straight line? My own opinion is that both wind and sea will, to use a sailor's phrase, "play the deuce" with your steering-blades and rudders, and that you will find extreme difficulty in propelling the ship on a given straight line. I daresay you have thought of that, and will be able to give us an answer upon that point also. As far as the structural details of the ship go, any person who has ever gone into engineering for a moment must be perfectly aware that they present no difficulty. There can be no doubt that you can have in that circular vessel a solid structure, that you can put upon that solid structure such armour plating as you think right, and that you can arm it with such battery as you think desirable, and make it a perfect floating defence. Last Monday there was an able lecture delivered here on the subject of floating forts and defences. A very excellent and practical gentleman, Captain Moody, gave us his views, through the medium of Mr. Mackie, a gentleman connected with the press, a very able writer and speaker, who gave, I thought, a most interesting lecture to the meeting on the subject of floating forts, and the facilities they offer, combined with land forts, for defence. Now, if your circular fort was content to abandon locomotion, there is in it, no doubt, something that will be extremely valuable, and which ought to be considered by those whose business it is to fortify our forts and harbours. My question and the few observations I have made—I am sure you will not suppose that they are put with a hostile feeling, or in a spirit of criticism—my object only is to obtain from you that kind of information which will enable those who are sailors to form some sort of judgment of the locomotive power of that circular ship. Without locomotive power, and without steering power, the value you would put upon it, and the value this meeting would put upon it, would be very much lessened, indeed. Therefore I say, without the slightest wish to daunt the inventor—without the slightest fear of embracing any novelty, provided that novelty can recommend itself to the mind and judgment of those who have to carry into practical effect the ideas and inventions of others—without in the slightest degree wishing to put these remarks in a hostile spirit, I make these remarks with the view of telling you the difficulties that occur to my mind, that you may, before we leave this room, give us some explanation on the subject.

Commander COLOMB, R.N.: I had intended to make some remarks, and I had made two or three notes, but the Controller has entirely cut away the ground from under my feet, because he has said almost everything that I should have said myself, and has expressed in far better words than I can do, the thoughts that crossed my own mind during the reading of the paper. The two points which he has adverted to are those which must have struck the mind of every person who listened,—the possibility of propelling such a vessel at a given speed, and the possibility of steering her when so propelled. In the early part of the paper, mention was made of experimental trials. I hoped at first, on hearing that mentioned, that we should have had more of the experiments and less of the suppositions. However, we had nothing, as far as I heard—I shall be corrected if I am wrong—we had nothing in the way of experiment except the towing of two structures, one against the other, at the end of a balance-rod across the stern of a boat. Of course that goes a certain way. But I must say that my own idea would have been that the only satisfactory way of ascertaining whether it was possible to propel and steer such a structure would be to have myself made an experiment on a small scale before submitting it publicly; and I question very much whether it would be possible to answer Admiral Robinson's questions, except by producing certain experiments. Of course, if those are forthcoming—and I hope we shall have them—then my doubts will be set at rest. I should say that while Admiral Robinson was speaking, a thought struck me with reference to the steering, which is in favour of that structure; that is, that wind and sea will operate equally on both sides of the line that you propose the ship to follow. In a ship which has greater length than breadth, of course the wind and sea will be acting in particular directions upon her; whereas in that ship, as far as I can see, there will be no more action on any one part than on any other. But that, perhaps, you will also advert to in your answer. If it is possible that such a ship can be driven at a speed equal to the present ships, with a lighter draught of water, and carrying a larger number of guns, as I presume she would carry, than the present ships for

their tonnage, then the advantages are such as utterly to startle us. It seems to me, if it is possible that that can be done, that we sweep away at a blow the whole of our ideas on nautical matters from beginning to end. Generally speaking, when such an idea comes across my mind, or is presented to it by the reading of any paper like this, I feel myself obliged to hold back and to keep my mind open, so as not to express a decided opinion either for or against such an extraordinary and novel proposal.

Mr. W. SMITH, C.E.: It seems to me that Admiral Robinson has forgotten that it is not a long box presenting that section throughout, but that the midship section, or section of greatest area, is only to be taken at one particular line, which of course is at the greatest diameter, but that, before and behind, taking the cross section, she should present exactly the same shape. It is a totally different thing from a box, with the same width and depth continued throughout any number of feet. If Admiral Robinson will consider it from that point of view, he will see that what appears to be an astonishing result, is almost self-explanatory, as being due to the remarkably fine buttock lines of these circular ships.

Admiral ROBINSON: I was not fortunate enough to see the experiments that Mr. Elder referred to; and of course I am a devout believer in the Baconian theory; but being a complete and thorough Baconian in my belief, I require rather a large induction before I accept it as satisfactory on any subject. One fact will hardly convey a general principle to my mind. Independently of that, I had not in the least overlooked the fact that this was a circle; and that the particular length I mentioned, 280 feet at the water line, if the diameter of the vessel was 300 feet, was something like the measure of resistance, or rather of the trench that the ship passing through the water had to dig out. But taking the lower part of that midship section, if the other be 280 feet, that lower part must be 140 feet. There is, therefore, though not immersed to a considerable depth, a greater amount to be pushed through the water than in an ordinary ship. I admit there are various refinements of the lines, as there are in an ordinary ship. I do not think that an ordinary ship is like a box. But granting that it were, granting that the ordinary ship did not divide the water forward by its fine lines, even the square box in my opinion—I will not say in my opinion—I would only ask the question whether a square box of 50 feet broad, with a perfectly square head to it, and 400 feet long, drawing 26 feet, which is the draught of the "Minotaur" class, would be more difficult to propel through the water than this, 280 feet at the water line, brought down to 140 feet at 13 feet below the surface of the water. I do not in the least wish to say anything dogmatic, or to assert that I have an opinion on the subject. I am a humble scholar seeking for truth, asking to learn and ready to be taught by anybody; and if Mr. Elder can show a large induction, a sufficient number of experiments to show a reasonable prospect of this invention being successful, there is no one will more rejoice than myself, and more ready to be on his side.

Mr. HYDE: I very much rejoice, indeed, that so able a man as Mr. Elder has presented to you a vessel or ship having a deflecting side. He has come to the conclusion, doubtless, that vertical structures are very vulnerable; and hence he has adopted a double angle all round his ship. It might be interesting to Mr. Elder if I were to show him the midship section of a vessel that is somewhat like the midship section which he has exhibited. I have no doubt he will agree with me that a ricochet shot, or a deflecting shot rather, is likely to do less injury upon a ship of his description, or of this, than any other. I simply call his attention to the fact that deflecting-sided vessels and structures have been for a very long time advocated as being the proper form on which such vessels should be constructed. I have no doubt he can tell us, and answer all questions as regards the probability of shots penetrating the sides of vessels at the angle he has adopted. Such information will be very useful.

Captain ALEXANDER, R.N.: From several remarks that Captain Colomb made, I am under the impression that he believed the plan proposed was for sea-going ships, in fact for all purposes of war; whereas I was under the impression that under present circumstances they were only proposed as sea-going movable forts; and any remarks I made for or against them, were in that view entirely, because I was not at

all prepared to consider them as sea-going men of war. I consider them capable of moving about from place to place on the coast, and even of attacking, but not as sea-going vessels.

Admiral ROBINSON: There is one gentleman in this room (Mr. Laird) whose opinion would be much more valuable than that of anybody else, who has had the greatest experience in designing and constructing ships, perhaps he will favour us with some observations.

Mr. LAIRD, M.P.: I think that the principal objection against the plan has been made by Admiral Robinson. I should like to hear that objection explained by Mr. Elder, how he intends to steer that vessel; also whether he intends it merely for coast defence, or for sea-going purposes. There is no doubt there are many advantages in the plan, and she can be made to turn rapidly. I do not quite agree with Admiral Robinson as to the difficulty of driving a vessel 280 feet wide. Therefore, after hearing Mr. Elder's explanation, if he will explain the objection Admiral Robinson has raised—the question of steering in a sea way—I think he may get over the other difficulty. I agree with Admiral Robinson that, in the statement made with regard to the "Minotaur" class, Mr. Elder has over-stated the midship section to be driven. But by comparing the actual midship section with the midship section of his own vessel, if he can steer the vessel straight, he will enable us in the present transition state of naval matters to get a powerful vessel. As Admiral Halsted says, I am taken aback. The steering appears to me to be a great difficulty. But if Mr. Elder can only steer the vessel straight, no doubt she will be very formidable.

A VISITOR: With reference to steering the vessel, I beg to say that I have to do with sliding keels, and I have found them very efficient in making a leeway, and also keeping a direct course on the ship with a shallow draught of water. Sliding keels are very beneficial to ships of shallow draught of water. The Honourable Member for Birkenhead has had experience with sliding keels, and he can give us some information on that point.

Mr. LAIRD: It is one of the points that I should like to allude to, with regard to the form of the vessel. There were great difficulties twenty-five years ago in navigating the river Indus. Vessels of common form with straight keels could not do it: they got aground, and could not be got off. I built a vessel of very much the same longitudinal section as that vessel, with two curved ends, and no dead wood at either end. Those vessels were found to answer better than any other; they possessed great speed, and they steered uncommonly well. Mr. Elder may have some means with his water-power of getting over that difficulty; and if so, I agree with Admiral Robinson that Mr. Elder has devised a powerful vessel.

Captain ALEXANDER: While the gentleman who spoke before Mr. Laird was mentioning a sliding keel, it struck me that there might not, to our mechanical engineers and ship-builders be so much difficulty in arranging a pivoting-keel fixed in the centre of the vessel, and turning round on its centre, being movable by machinery. So that in any direction in which it might be proposed to propel the vessel, the keel might be moved to suit the purpose of the intended direction of the vessel.

Mr. ELDER: With regard to the remarks about this being a sea-going vessel, the experiments I made were with a very small ship indeed. It was an open boat built of copper. The vessel that I experimented upon along with that, was of a similar form to iron-clads, with the same proportions as to breadth, length, and depth. I towed them in all manner of seas that I could tow them in, and in the wake of steam-boat paddles. The circular ram-boat rode over the top of the wave in an elegant manner: it slid down into the hollow of the wave, and rode over the top of the next wave, and never shipped a drop of water. Whereas, the open boat in the ordinary form was very soon swamped. The two boats were made of the same weight. They were towed at the stern of a pulling boat at a velocity relative to that necessary to overcome the resistance which vessels on a larger scale would have had to encounter. The scale beam was a beam 10 feet long, with a fulcrum in the middle. The fulcrum was pivoted in the stern of the boat. I pulled my round boat, and the open boat with that scale beam, and as near as may be, the natural velocities

of the two were about a balance. I was convinced then that there was no great reason to object to the round shape on account of its resistance. Then with regard to its behaviour in the waves, I tried them in the very worst form of wave I could put them in.

Admiral ROBINSON : What was the size of the boat ?

Mr. ELDER : About 5 feet in diameter.

Admiral ROBINSON : A circle of 5 feet in diameter ?

Mr. ELDER : A circle of 5 feet in diameter. I was very much pleased with the behaviour of the circular boat. I must say that I am not enthusiastic, or in favour of any one thing—I try to keep clear of that—but the object to be gained by such a ship was so great, viz., that of having a vessel of immense stability, and one that could move in any direction from a state of rest without turning, for instance, that could move right up between two lines of ships, and also go across them, or go in fact in any way that the commander of the vessel might want it to go, that I thought that was a great advantage, and it might be of very great use, if it could be accomplished. With regard to the midship section which the Controller of the Navy spoke of, he must recollect that the vessel is about at least half as large again as any ship in Her Majesty's Service in dimensions. It seems that I was mistaken as to the draught of water of the "Minotaur" class. That was given to me; the draught of water as given to me was 30 feet.

Admiral ROBINSON : It would not affect your argument much. I only wished to put you right.

Mr. ELDER : I am much obliged to you, for I really am not responsible for the statement. But this vessel has 120,000 cubic feet.

Admiral ROBINSON : Of immersed area ?

Mr. ELDER : No, the cubic capacity of the total ship. The total weight afloat is 16,300 tons. Now, I do not think that the largest class ship in the Service is more than 10,000 tons.

Admiral ROBINSON : The largest is 10,900 tons.

Mr. ELDER : At all events, you are comparing the "Minotaur" with a ship which is one-half larger in weight. You will find that she is not only one-half larger in weight, but that she has double the capacity, for stores and crew, and will be able to carry ten times the amount of coal. She will be able to go to America and back without coaling. With regard to the steering, if the case is a good one, we shall not stick for want of some efficient steering gear. Here is the centre of gravity of the ship, if you cause the propelling pressure to act upon this point in any direction, the vessel will certainly be impelled in the said direction whether she is revolving or not. One gentleman has asked what would be the effect if a sea did strike her. Supposing a sea did strike her, the vessel may change her course a little. But then the man in the steering turret, which is placed at the top of the sluices, will immediately open the sluice on the other side; and that self-acting turret has machinery which opens the sluices. I think Admiral Robinson was not here when I described that arrangement of sluices. (Admiral ROBINSON : No, I was not here.) The turret is driven by a donkey-engine. All the pilot has to do is to put the pointer in the position he wishes the vessel to go. That pointer opens the steam to the donkey-engine of the steering turret, and causes it to revolve till the turret points to the direction wanted, and in its course of revolving opens the sluices commanding the jet or jets behind the steering turret. The ship should then move in the required direction. If he finds she will not go exactly as expected, all he has to do is to counter her a little. The steering of the ship is not dependent upon the rudders; the rudders are merely a preliminary appendage. That is the system of steering. But if I have not accomplished it, it is for you to do it, though I feel thoroughly confident that I could do it, and I think the machinery I have prepared would accomplish it. With regard to the resistance of the vessel, I must speak from what I know, and that is described in my paper. With regard to the thickness of the armour upon the ship's deck, the ship has such an enormous displacement, that, suppose you put 6 inches of solid armour there, she would only draw 4 feet more water; 18 feet instead of 14 feet, but it is for artillerists to say whether 6 inches of armour for a flat deck is necessary. However, practice will bring that about. It is not for us to

say that we should stop there if there are other advantages that would enable us to struggle with such a difficulty. With regard to the peculiar form of the resistance, of course theorising upon it, is not so good as experiment. But you can understand that if this ship were divided into parallel strips, each of those strips would present a ship with a curved bottom to it ; and each of those ships would please every man present as a good form of ship. Why then, when so many ships separately are good, are they any the worse when they are put together? I cannot understand. The resistance is of course less when the strips are put together than when separate. I believe that this system of hydraulic power is preferable to screw-propellers in such ships on account of its capability of steering the ship thoroughly, because you can steer it in all the various directions you wish to go. For instance, this ship can find her way into the most complicated channel; it will go round the most abrupt corner; and with regard to her draught of water, she would find her way into any harbour, where almost every other ship would have to stop outside. Therefore I think it possesses great advantages on account of that. With regard to its revolving tendency, there cannot be the smallest doubt that if a vessel can be revolved, and at the same time run up between two lines of ships and fire into both sides, it would be a very great property, and I think it can be obtained. With regard to exceptional fighting, I have no doubt this may be a good ship for exceptional fighting. My opinion is that it is more fitted for exceptional fighting than most gentlemen believe. I should like to see it put to the proof. Make the vessel, give it hydraulic power, and ascertain at what speed it will go. I believe you can get vessels of this class that will go 10 and 11 knots, and be able to carry an amount of fuel that will take them across to America and back again. With regard to the edges of the vessel, there is no doubt that the strength of this edge is very considerable, and there is not much of that to fire at. The vessel is very low in the gunwale, and there is only about one-eighth of an inch of edge for the shot to strike. If the shot strikes above, it will, I believe, fly over the ship ; if below, it will, I believe, go right into the water. There is very small chance of the ship being damaged ; and if it is struck, there is a water-tight ring all round the periphery, so that the internal portions of the ship will be perfectly water-tight. With regard to the power of sawing, it is a queer thing to think of sawing a ship when you come in contact with it. But certainly this ship will go round at the rate of about 25 miles an hour. There are about 1,500 tons of armour in its periphery, and it is all riveted together, and that amount of 1,500 tons going at the rate of 25 miles an hour, coming into collision with a ship even at a small speed will, I think, do considerable damage.

Captain W. J. WARD, R.N. : It will require a fulcrum.

Mr. SMITH : That is what the Controller pointed out, that it has such a large and uniform bearing surface.

Mr. ELDER : That is one great advantage in this knife-edged side ; besides being able to resist shot, its shape for attacking makes it a very formidable vessel. I have made arrangements with screw propellers for the same thing. You can put a couple of screws, one on each side if necessary, and there might be a screw propeller at each end. However, that is a matter for you, gentlemen, to improve upon. All I can say is, that I think this may be made a useful ship for our country ; I hope it will be so. It will be my greatest pleasure to hear that it has been successful, and that it has answered some service.

The CHAIRMAN : I must confess that I am one of the gallant Admiral's class, I am completely taken aback, so that nothing more can come from me than to request you to return your thanks to Mr. Elder for this paper. I may also mention that this is not the first time that he has favoured us with a paper in this theatre. We had from him a very valuable paper on "Marine Engines." We are therefore extremely obliged to him for coming again.

## LECTURE.

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Friday, June 19th, 1868.

GENERAL HIS ROYAL HIGHNESS THE PRINCE OF WALES,  
K.G., G.C.S.I., &c., &c., Vice-Patron, in the Chair.

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### COAST DEFENCES, AND THE APPLICATION OF IRON TO FORTIFICATION.

By Colonel JERVOIS, R.E., C.B., Deputy-Director of Works for  
Fortifications.

#### *Introduction.*

THE principles on which fortification has been applied to the defence of this country have lately been so much discussed, and so many changes in the science of attack and of defence have occurred during the last few years, that I readily acceded to a request, with which I have been honoured by the Council of this Institution, to lecture upon the subject, popularly (or perhaps I should say *unpopularly*), termed "Coast Defences," of which the application of iron to fortification now forms an important part.

It will be impossible within the limits of a lecture to give an exhaustive view of the points which it will be desirable to consider; I can only now pretend to *touch* upon the several matters which form the elements of Coast Defences, and to shew, as far as the time at our disposal will permit, the relation which the several elements bear to one another.

The Navy first, the regular Army next, the Reserve Forces, the Militia, and Volunteers, fortifications and floating batteries, combined with and supplemented by submarine mines, are each and all parts of the general system for our "Defence."

The positions and the degree in which each of these several means should be applied is a very difficult problem, and one which it is necessary to consider without prejudice for one arm of the service over another, or for one principle to the exclusion of another principle. To provide an efficient system of defence at the least cost to the State, the sailor, the soldier, the naval architect, the artilleryman, and the engineer, must each occupy his proper place.

For the general defence of the empire we must, of course, look first of all and mainly to our fleet. If our Navy could be kept up in sufficient strength to meet the Navies of other nations at all points that hostile fleets or cruisers might attack us, questions about invasion or attack upon ports and Naval Arsenals would be disposed of. Very little reflection and calculation, however, is necessary to show that the resources, even of this country, whether in money or in seamen, would not admit of our maintaining such enormous Naval means as would of themselves suffice at once to protect our commerce, to prevent an enemy landing on our shores, or attacking our widely scattered naval and commercial ports, whether at home or abroad. Other defences *besides* the Navy are essential.

*Defence of Naval Arsenals and Harbours against Attack by Land.*

We maintain in Great Britain a large military force of Regulars, Reserves, Militia, and Volunteers, and thereby admit the possibility of a campaign taking place in this country.

The landing of a hostile Army on our coasts must be admitted to be a difficult operation; but it would, to say the least, be very unwise if we were to conclude that invasion is impossible because it is difficult.

It must be assumed that the main object of an enemy in an invasion would be to get to London, for by doing so he would not only occupy the commercial heart of the Empire, and the seat of Government, but the main military arsenal of the empire, at Woolwich, would also fall into his hands.

Supposing him to have obtained a footing on shore, and to be advancing on London, we interpose between him and his object the Regular Army, in conjunction with the armed and organized manhood of the country more or less disciplined, and aided by such temporary defences as could be thrown up in support of the field of battle at the time of expected attack.

But as the best disciplined and the greater part of our military forces must be employed to cover the capital, we must arrange our plan of defence so that as few disciplined troops as possible may be necessary for the defence of other points in the country which must be defended, but which cannot be covered by the operations of the main Army.

Portsmouth and Plymouth, for instance, are therefore defended on the land side by the aid of fortifications which will enable a comparatively small number of partially disciplined forces, with the aid of a few regular troops, to protect those places against capture or bombardment, whilst the main Army would be employed in the defence of London and Woolwich.

A mistake is commonly made that because the stations I refer to are fortified, the garrisons of those places must be largely increased. The case is precisely the reverse.

Supposing all the outer line of forts to landward at either Portsmouth or Plymouth to be fully manned at the same time (which would be quite unnecessary—not more than one-half need be fully manned at the

same time), only between 6,000 and 7,000 men would be required for the purpose at each place respectively, and only a very small portion of these need be regular troops. The remainder of the garrisons would consist of a moveable force, which in any case we *must* have for the defence of these places, but which in the absence of the forts must be of sufficient strength and sufficiently disciplined to meet the enemy in the open field, whilst *with* the forts it may be comparatively small in number, and only disciplined to take up a fighting position, under the support of the works, at that part of the fortified line assailed.

*Unfortified*, an enemy would only have to detach about 15,000 or 20,000 men from his main invading army to effect in a few days the destruction of all our ships and naval establishments at Portsmouth; fortified, he must employ an Army of at least three times that number, and must have a considerable time at his disposal to undertake a regular siege.

*Unfortified*, no force that, in the case referred to, we could afford for the garrisons of these places could protect *either* against the attack of 15,000 regular troops. Fortified, there is no difficulty in providing the numbers and description of troops that would be capable of making a good defence of these nurseries of the Navy.

*Unfortified*, they at once fall if an enemy were to obtain a decisive victory over the Army in the field; fortified, they remain in our hands even under such untoward circumstances, and thus enable us to avert the destruction of our naval power at a period when all the resources of the country would be required to enable us to retrieve the position we had temporarily lost.

The foregoing observations refer to the extended lines of works which cover our naval arsenals against attack by land. We have other defences against attack by an enemy on shore (for instance, the fort at Newhaven), which have for their object to prevent an enemy, who may have been enabled to land a comparatively small force, obtaining possession of harbours which, exceedingly valuable to us, as sheltering our cruisers and squadrons against attack by a superior force at the particular point assailed, would be admirable bases of operation for an enemy to harbour his men-of-war and transports for landing an Army, especially the artillery, cavalry, and stores.

With the harbours on our coast thus defended, invasion becomes much more difficult, owing to the enemy being thrown upon the open beach to effect a landing. The works for the defence of these places absorb only a small and a partially disciplined force.

I have made these observations in the first instance respecting fortifications which provide against attack by an enemy on shore, in order to avoid any chance of their being mixed up with defences which are required for the purpose of resisting naval attack.

The former are not liable to be attacked by iron-clads and big guns, and their armaments may be of a comparatively light description.

As regards attack by land, we have to provide against the great range, accuracy, and penetration of rifled ordnance; but the ordnance used by a besieger must still be comparatively light. Such pieces as



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Fig. 1.

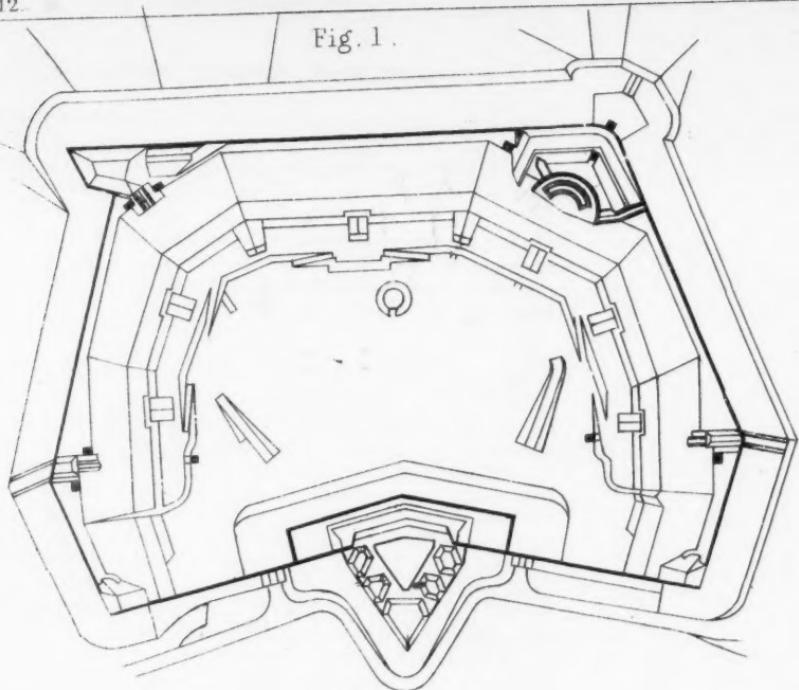
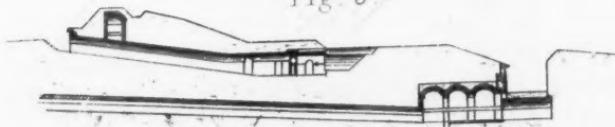


Fig. 3.



SECTION THROUGH WORK

Fig. 5.

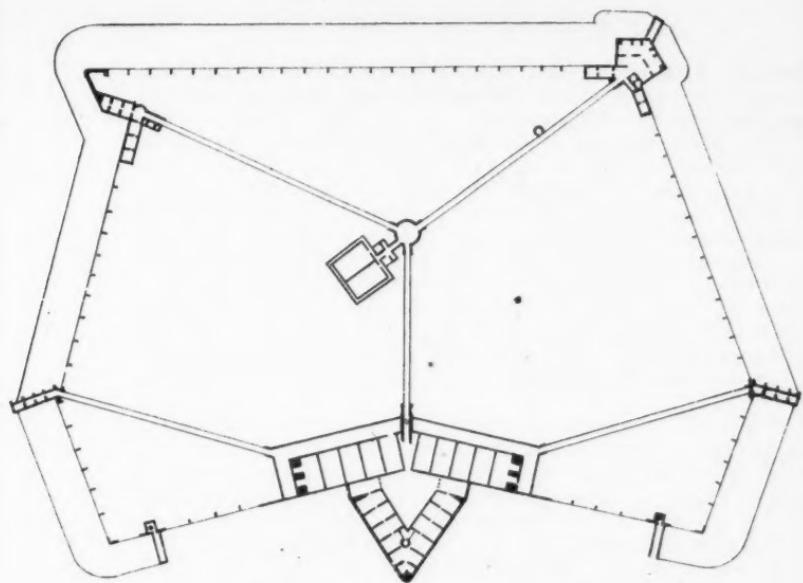


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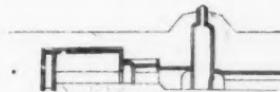


Fig. 2.



UNDER PLAN

Fig. 4.



SECTION THRO' MAGAZINE

Fig. 6.



FRONT ELEVATION

Section for Plans and Elevation 2500



Scale for Sections 1:250





our 12-inch or 600-pounders, weighing 23 tons,—as the 10-inch or 400-pounders, weighing 18 tons,—as the 12-inch or 250-pounders, weighing 12 tons,—or as the 7-inch or 115-pounders, weighing 7 tons,—together with the ponderous ammunition for them, cannot be dragged about on land.

It was the armour-plating of *ships* that caused the introduction of these great guns, and it is *in ships* and *against ships*—not *in forts* or *against forts* intended only to resist land attack, that they are required to be used.

*Description of one of the new Forts intended to resist Land Attack.*

This appears the proper place to describe one of the forts lately constructed to resist attack by land. I will take, as an example, Fort Purbrook, a work on the right of the chain of forts occupying the Portsdown position. (Diagrams of this work are shewn in Plate xxxi).

The rampart is a massive earthwork, with a deep and narrow ditch in its front (Figs. 1, 3, and 6). The trace of the rampart does not follow the line of ditch, but is arranged so as to afford a fire of artillery and musketry nearly equally upon the front and flanks, whilst the ditch is arranged so as to complete the enclosure with as few sides as possible, in order to simplify the arrangements for flanking it.

The rampart is so retired from the escarp (see Fig. 3), that the continuation of its exterior slope strikes about two-thirds down the escarp wall; thus, even if the escarp were breached, the rampart would not be brought down. At the top of the escarp is a *chemin-des-rondes* wall, which, besides raising the height of the escarp, would prevent any portion of the rampart that might be brought down by the fire of shells from falling into the ditch, and would enable the rampart to be reformed.

At intervals on the rampart (Fig. 1), bomb-proof shelter is provided under traverses, beneath which again are small magazines for the immediate service of the guns. Shell stores and shell-filling rooms behind the rampart may be added at a time of expected attack, or, if necessary and funds were available, may be constructed permanently. It is to be observed that in works to resist land attack, there is not the same necessity as in sea defences for these last named preparations being permanently made.

The parapet (Fig. 1) is at present left without any of the usual arrangements of embrasures, platforms, and racers for guns, so that if the Moncrieff carriage (to which I will hereafter refer more particularly) is adopted into the service, this system for mounting artillery may be applied. The Moncrieff carriage will not, however, admit of protection against vertical fire; it, therefore, appears desirable that at the shoulders and salient of the work, casemated batteries for three or four guns each, and covered with iron to the front, should be provided at a time of expected attack. We should thus have artillery fire over the whole space in front of and on the flanks of the work protected, on the barbette principle of Moncrieff, against direct fire, and protected

both against direct and vertical fire by the iron-fronted casemated batteries. This I believe now to be the principle which should be adopted in the arming of fortresses intended to resist land attack.

It has often been suggested that iron turrets should be applied at the salients of land works; but I do not think that any advantage would result from such application, sufficient to compensate for their great cost. We do not require to follow up the siege battery or attacking force on land, as we do the moving vessel at sea; and so one of the great advantages of the turret does not apply to works intended only to resist land attack.

The ditch of the work (Figs. 1, 2, 3, 5) is flanked by caponiers for guns and musketry, which, being well sunk, and perfectly secure against being struck by an enemy's direct fire, are of slight construction, except as regards the roofs, which are bomb-proof.

It is sometimes urged that iron should be applied to protect the caponiers, and the flank defences of ditches from the breaching effects of rifle guns from long ranges. This is, however, unnecessary, if, as in the case of our new works, the flank defences are covered by high counterscarps, and are so arranged, that their prolongations cannot be taken up.

To the rear (Figs. 1, 2, 3), where the work is not subject to the artillery fire of an enemy, the escarp is exposed, and at the centre of the gorge (Fig. 2) is a casemated barrack with a projection in its centre called a redan, which flanks the rear of the work, and also brings an artillery fire to bear over the rear of the position.

Underground galleries of communication (Fig. 2) connect the casemated barrack with the caponiers flanking the ditch, and a staircase in a central position (Figs. 2, 3) leads from the galleries to the terreplein of the work.

The main magazine (Figs. 2, 4) is placed underground, off one of the galleries, and near the bottom of the central staircase.

Fig. 6 is an exterior elevation of the work, and shows the appearance it would present to an enemy attacking it.

#### *Defences against Naval Attack.*

I will now proceed to consider defences against naval attack.

To provide against naval attack on a port during the absence of the fleet, big guns, with all the numerous accessories for their service, are necessary; and these must be placed in positions so protected and arranged as to give them a decided superiority over the artillery of assailing ships.

The question then arises whether they shall be placed afloat in strongly protected vessels, *i.e.*, in floating batteries; or at fixed points either on land or on shoals, *i.e.*, in forts.

The proposal to defend our ports against naval attack by floating batteries alone, implies however, that we must maintain at each of our chief ports a naval squadron sufficiently powerful to resist, during the absence of our sea-going fleet, the attack of a superior force of the enemy. Then arise the questions, what *is* a sufficiently powerful force

to maintain at each point for this object? what would be its first cost? in how many years will it be necessary to repeat the outlay for it? what will be the expense of its annual maintenance?

It is impossible to examine these questions without arriving at the conclusion that even if our resources in money and in seamen rendered it practicable to maintain such a force in addition to our sea-going Navy, the defence of our ports can be effected much more efficiently and economically with the aid of other means. As on land, fortification enables us to economize in troops; so, on the sea-coast, we can, by the same means, economize in ships by providing for the protection of our harbours against naval attack.

Irrespective, however, of the question of the expense of providing for coast defence by floating batteries alone, very little consideration is requisite to understand, that if there be positions on land from whence an effective fire can be brought to bear on the channel, anchorage, or shore to be defended, there is no object in placing the guns in vessels afloat.

In positions such as I have referred to, there cannot be any object in substituting an unsteady platform on which the amount of protection that can be afforded is limited by considerations inherent to floating structures, and which is liable to be taken away or to be sunk, for a fixed and perfectly steady platform on shore, which can be fully protected, either against its fire being silenced, or from capture by an enemy.

In cases, however, where the distance between forts is so great that the intervening space cannot be properly commanded by their fire, or where it may be necessary to have advanced batteries of artillery at a distance from the shore, and where foundations for fixed works cannot be obtained without expense and difficulty disproportioned to the object, it becomes *necessary* to employ floating defences.

In short, we must, in each case, consider—

1stly. Whether we can provide for the defence by forts *without* floating batteries.

2ndly. If not, to what extent floating defences should be applied in conjunction with forts. And

3rdly. Whether the circumstances are such as to render it advisable to employ floating batteries in *substitution* of forts.

The question is not one as it is often put, of “floating batteries *versus* forts.” There is no “versus” in the matter. Both are required in their proper places.

Whether, however, the batteries for the defence of our harbours be fixed or floating, submarine mines, of which I will presently speak more particularly, should be employed in conjunction with them.

#### *Description of Vessels adapted for Harbour and Coast Defence.*

The question of the *kind* of floating battery to be employed for harbour defence has from time to time been much discussed.

Ten years ago, at my suggestion, a Committee was appointed by General Peel to consider the subject. Admiral Cooper Key, Colonel

Wilmot, R.A., and myself were the members of this committee. We then recommended the employment for harbour defence, of small vessels, each carrying a fixed iron tower for four guns, and provided with eight ports. It is curious how nearly this vessel approached the "Monitor" type first used in the memorable fight at the mouth of the James River, in America in 1862. I believe it is generally admitted that the "Monitor" class of vessel is the best kind of armour-clad floating battery for coast defence, but amidst the many projects for defensive floating structures now advocated, I do not offer a decided opinion on this subject. In some cases iron-clad "Monitors," supplemented by a mosquito squadron of gun-boats, might be employed, and to oppose unarmoured cruisers or privateers (to the attacks of which alone the less important harbours would be liable), small gun-boats of light draught, in conjunction with submarine mines, would alone suffice. I have here a model of a small gun-boat for one gun, proposed by Mr. Rendle, of the Elswick Ordnance Company, which appears admirably well adapted for the small class of vessels for harbour defence.

#### *Obstructions.*

Another and a scarcely less important element of coast defence than either forts or floating batteries, is that of obstructions, which are now in most cases essential to keep an enemy's ships under the fire of the guns of forts.

Obstructions are of two kinds, passive and active.

#### *Passive Obstructions.*

Passive obstructions may consist of rafts or barges, booms of timber, chains, nets, wire, or rope, sometimes (in places which it is unnecessary to keep open) of piles, stones, dams, or sunken vessels. The attention that has been given during the last few years to the application of submarine-mines has, however, rendered it improbable that we shall find it necessary to use *passive* obstructions.

#### *Active Obstructions.*

Active obstructions, or submarine-mines have become of especial importance since iron-armour has been applied to the sides of ships of war, these vessels being most vulnerable in their bottom. Submarine-mines should, as I have just stated, be placed between the forts or batteries on either side of the channel which they are intended to defend. They may also be employed in connection with either fixed or floating batteries, to prevent an enemy occupying any particular position within range of the guns from which it is desired to exclude him. Attempts had been made by the English so early as the 17th century, to apply floating and submerged charges of gunpowder for purposes of offence and defence. The Russians in 1855, however, were the first to apply explosive machines of this kind with any approach to success; and, although the mechanical self-

acting torpedoes which they laid down in the Baltic were somewhat defective of construction, there is little doubt that they might have produced disastrous effects upon our ships, had the charges of gunpowder employed in them been sufficiently large. The Russians were also the first to attempt the employment of electricity for the explosion of torpedoes, though their arrangements for this purpose never appear to have been placed in position for actual use.

The successful results attending the employment of torpedoes as engines, both of attack and defence, by the Americans, and more especially by the Confederates in the recent war, have attracted considerable attention to these engines of destruction. Though the means at command were limited, and the arrangements generally of very crude description, there are official records of the destruction of no less than 24 ships of the Federal States, and of the injury of 9 others by means of torpedoes. The progress made in the application of these mines during the Civil War in America, is shown by the fact that whilst in the year 1862 only one Federal vessel was destroyed, in the first four months of the year 1865, eleven were destroyed or sunk, and four injured.

If it is considered that the area of water or passage to be defended may be perfectly closed against *friendly* vessels without disadvantage, the employment of torpedoes which are exploded by self-acting mechanical contrivances present advantages over torpedoes which are exploded by electricity, as being less costly, and more expeditiously placed in position.

This class of explosive machine would be of a size to contain about 150 lbs. of powder; and would be so moored as to be within range of the bottoms of vessels of small size. They can be fitted up and placed in position with great expedition, and, their cost being comparatively small, their number could be so large that even the most careful search after them by the enemy would fail to render a water safe to their ships.

These mechanical torpedoes are, however, altogether inapplicable in positions where it is desired to keep the water open to friendly vessels, and to close it effectually against an enemy.

In such instances it is indispensable that submarine mines should be arranged to be exploded by electric currents.

Electric torpedoes or mines may either be self-acting, *i.e.*, their explosion may be accomplished by the collision of a ship with them, or with a mechanical arrangement floating near the surface and connected by an electric cable with the mine beneath; they may also be exploded at will by operators on shore, when a ship is observed to be over them or in their immediate vicinity; or they may be so arranged, that the collision of a ship with the self-acting mechanism with which they are provided, will instantly give a signal at the station on shore, whereupon the mine may be at once exploded by the operator at the station. Lastly, the torpedoes may, by simple means, be so arranged, that they may be either exploded spontaneously by a passing ship, or at the will of the operator on shore, in the possible event of the ship not coming into contact with the self-acting trap.

The torpedoes would be placed several fathoms below the surface, and at such distances apart that the explosion of one would not injuriously affect those in its vicinity. Their charges would be sufficiently large to ensure the destruction of a ship by their explosion, not merely when immediately over one of them, but even if any portion of her were within 40 or 50 feet of that position. It is obvious that by arranging the torpedoes in two or more chequered lines, a vessel, even if passing harmlessly between two torpedoes in one line, must come within destructive range of a torpedo in the second or the third line. The placing of torpedoes at considerable depths, and their arrangement for optional explosion from on shore, must render it extremely difficult for an enemy to interfere with such a defensive arrangement, and such interference is impossible if the area of water defended, is guarded by artillery. It is often stated that the torpedoes may be removed at night, but this objection is effectually met by lighting up the channel by the electric or other lights which may be employed for that purpose.

The knowledge and experience acquired within the last few years regarding the application and effects of explosive agents more destructive in their action than gunpowder, have demonstrated that some of them, and especially gun-cotton, may be advantageously employed in submarine mines. The Austrians used gun-cotton as the explosive agent in torpedoes, which were applied by them to the defence of Venice, and the results which they obtained in experiments with these, indicated that a submerged charge of 400 lbs. of gun-cotton produced destructive effects at least equal to those obtained with 1,000 lbs. of powder. Improvements recently made by Mr. Abel, the eminent chemist of the War Department, in the preparation of gun-cotton, have led to a very considerable reduction in the space occupied by a charge of that material, and experiments with the new form of gun-cotton, have demonstrated that very important advantages, both as regards destructive effect and reduction in weight and dimensions of a charge, are secured by the substitution of gun-cotton for gunpowder, as the explosive agent in torpedoes.

The submarine mines I have referred to, are all stationary, and strictly defensive in character. Torpedoes may, however, also be used offensively by means of small vessels specially constructed for the purpose, to which these mines may be fixed at the end of a long pole, and an enemy's ship thus sunk by ramming.

In order to ensure the ready application of these means at a time of impending attack, the necessary arrangements for their construction should in each case be well considered and matured beforehand, and, as is now being done, Officers and men of the Royal Engineers, as well as in the Navy, should be specially trained to ensure their proper application.

Six years ago, being much impressed with the necessity for having well matured plans for employing obstructions and torpedoes in the defence of our ports, I submitted to Lord de Grey, then Secretary of State for War, that a Special Committee should be appointed to consider and report upon these questions.

Lord de Grey at once recognized the importance of such an enquiry, and appointed a Committee which has up to the present time been engaged in this duty, and I beg to say that its labours have been conducted none the less efficiently because they have been prosecuted quietly.

The Committee, after making many experiments, have already reported on one branch of the subject, viz., that of passive obstructions, and their report on active obstructions, or submarine mines, is just completed. By the labours of this Committee, consisting of Col. Askwith, R.A., Captain Horton, R.N., Lt.-Col. Fisher, R.E., Captain Brandreth, R.N., Jas. Fergusson, Esq., and last, not least, Mr. Abel; by the experiments also which have been carried on by the Royal Engineers at Chatham, under the able direction of Colonel (now Major-General) Simmons, and by the Royal Navy at Portsmouth and Plymouth, the public service has greatly benefited as regards the development of this formidable adjunct to our national defences.

*Torpedoes must not be regarded as substitutes for Forts and Batteries.*

The question then arises, how far, if at all, does the use of submarine mines affect the employment of forts and batteries for defence against naval attack?

I answer that forts and batteries are still required in all important cases to cover the torpedoes, and prevent their being tampered with. It must also be remembered that whilst the submarine mine is harmless unless the ship comes near it, the shot from the battery can injure the ship whatever may be her position within effective range.

Further, although probably our harbours might be efficiently obstructed by torpedoes in at from 7 to 14 days' notice, yet one condition is that the weather should be sufficiently favourable to allow of their being exactly laid. There are again certain positions where even if the torpedoes *are* laid they might be disturbed by a violent storm, and possibly an attack on the positions in which they were to serve, *might* take place before they could be renewed, and though the periods of the year at which these difficulties might arise are short, yet the bare possibility of interference in the application of a complete torpedo system, prevents our placing entire reliance on such a defence for the protection of places on which the warlike power of the nation, both for offence and defence, must in a great measure depend. Therefore, although submarine mines are a most important element in the defence of our harbours and coasts, and add greatly to the power of our forts to resist a naval attack, yet they must not be regarded as substitutes for permanent works of defence at our Naval Arsenals and Harbours, and other important ports.

Submarine mines would not only be of immense advantage for the defence of our harbours in time of war, they would also, in conjunction with small gun-boats, be most valuable for the protection of places on the coast, like St. Leonards or Brighton, against privateers who might, perhaps, in the absence of other defence (which in these cases cannot

be applied on shore) levy contributions upon the inhabitants of these and other watering places.

*Construction of Forts and Batteries to resist Naval Attack.*

We now come to consider the construction of forts and batteries to resist naval attacks.

Before considering batteries for guns, I must first refer to the advantage, in some cases, of vertical fire, where it is desired to prevent an enemy occupying a certain anchorage. The deck of the ship, like the bottom, is completely vulnerable, and judiciously placed batteries if armed with a sufficient number of mortars, throwing "bouquets" of shells into the air, would be so excessively disagreeable that an enemy would no doubt hesitate to take up a position where he was liable to such treatment.

The Royal Artillery, have under consideration a rifled howitzer, which will afford vertical fire with accuracy, whereas mortar fire is somewhat wild and dependent on quantity for its effectiveness.

The simplest form of battery for guns is one to fire *en barbette*. (Figs. 1, 2, plate xxxiii.) In this case there is no difficulty about the construction of embrasures, the requisite protection for the guns and gunners against horizontal fire being obtained by an unbroken parapet. The exposure to which the Artillery would be subjected in batteries on a comparatively low level, if the guns were always seen above the parapet, renders it undesirable, however, to construct batteries *en barbette*, except at a considerable elevation, say about 100 feet above the sea, in which case the guns and men working them are scarcely seen from seaward.

It is, however, undesirable in any case to construct batteries *en barbette* where they would stand out in strong relief against the sky line.

The advantage of a barbette battery is the great extent of lateral range of the guns which can be obtained, and it is a question on which differences of opinion have always arisen, according to the taste of the individual, whether it is better to obtain this at the probable expense of gunners' lives, or to have a limited amount of lateral range, coupled with greater security. I believe that about the limit of the application of ordinary barbette batteries, is the elevation above the sea, to which I have just referred.

For the better protection of artillery in batteries at low elevations, the guns themselves, instead of being arranged so as always to show above the rampart, are placed *behind* the parapet, in which cuts or embrasures are made to fire through (Figs. 1, 2, plate xxxii), as at Lumps Battery, Southsea. Here the throats of the embrasures are nearly in the middle of the parapet, so that the merlons between the guns act the part of short traverses, separating gun from gun, though not separating the rear parts of the platforms. The plan of forming the parapet in this manner, moreover, admits of the guns being covered over by "blindages" of timber and earth, for protection against shells exploding over the guns and gun detachment. The necessity for further



Fig. 1.

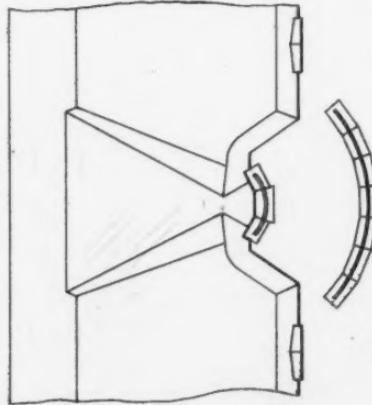
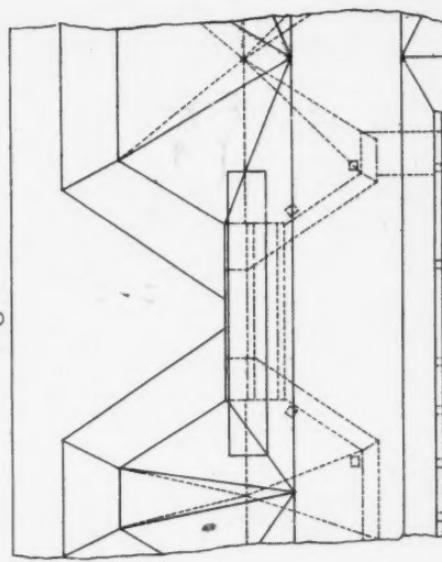
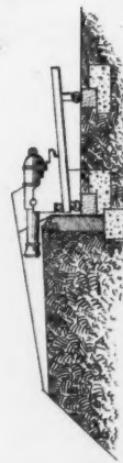


Fig. 2.



EARTHEN EMBRASURE (OLD TYPE)

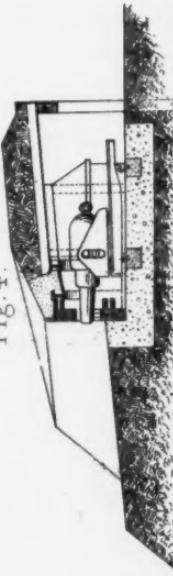
Fig. 3.



SECTION OF FIG. 1.

SHIELD EMBRASURE, WITH SPLINTER PROOF COVERING TO GUN.

Fig. 4.



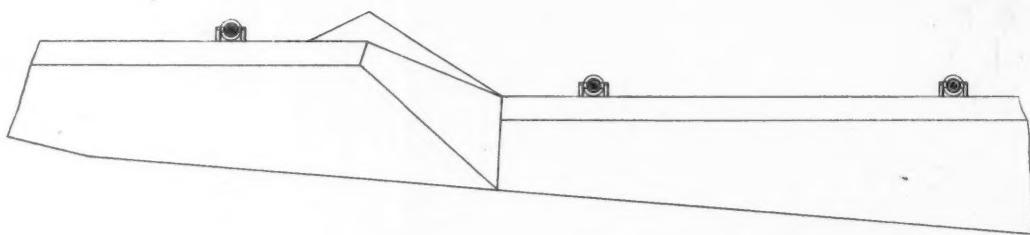
SECTION OF FIG. 3.

SCALE 20 FEET = 1 INCH.  
10 20 30 40 50

10 5 0 10 20 30 40 50

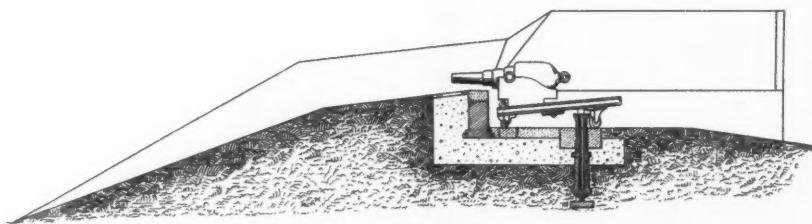
100  
1000

Fig. 1.



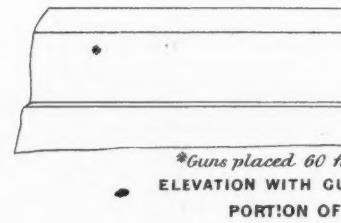
PORTION OF A BARBETTE BATTERY.

Fig. 2.



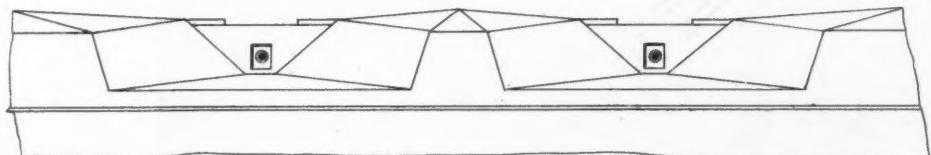
SECTION OF BATTERY SHEWN IN FIG. I.

Fig.



\*Guns placed 60 ft.  
ELEVATION WITH GUN  
PORTION OF

Fig. 6.

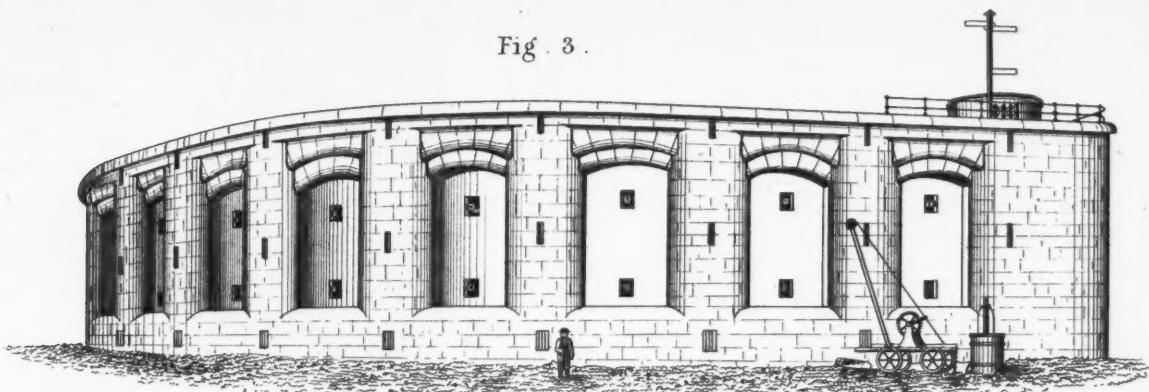


PORTION OF A BATTERY WITH EMBRASURES AND IRON SHIELDS

SCALE 20 FEET =



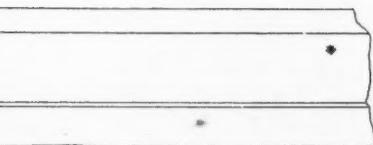
Fig. 3.



VIEW OF GARRISON POINT FORT.

(compiled from a Photograph.)

Fig. 4.

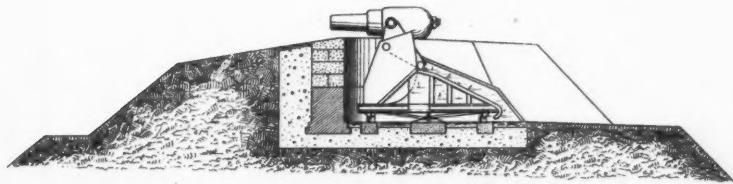


placed 60 feet apart.

WITH GUNS RECOILED

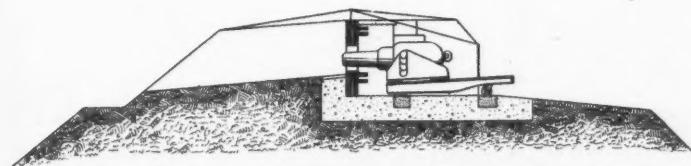
PORTION OF A BATTERY FOR GUNS MOUNTED ON THE MONCRIEFF SYSTEM.

Fig. 5.



SECTION SHEWING GUN IN FIRING POSITION.

Fig. 7.



SECTION OF BATTERY SHEWN IN FIG. 6.

20 FEET = 1 INCH.

0 50 60 70 80 90 100

J. Jobbins



strengthening the embrasures has led to placing an iron shield in the opening of the embrasure. (Figs. 3, 4, plate xxxii., and Figs. 6, 7, plate xxxiii.) The cover between the shields, however, if composed of earth alone, must necessarily be comparatively weak, more especially at the junction with the shield, and in order to afford the requisite resistance, should be also strengthened by introducing masonry, brick-work, concrete, or other suitable material.

Indeed, in all cases in which the space will not admit of the requisite degree of strength being obtained by the additional thickness of earth necessary to resist modern projectiles, the plan of inserting Portland cement concrete, a wall, or perhaps a thin iron plate, in the interior of the parapet should be adopted.

Even where there is no limit with respect to space, if earth is not procurable at reasonable cost, or if the breadth of the work cannot conveniently be made sufficient for an earthen parapet, as for instance on a narrow headland, or on a foundation constructed in the water, it may be necessary to employ other material.

In these cases, masonry or brickwork alone was formerly applied to the construction of batteries.

Masonry *alone* is, however, no longer admissible at the embrasures of works; as in the case of earthen batteries, iron must be substituted at those parts of the work which must necessarily be thin, in order to allow of sufficient lateral range and space for the efficient working of the guns.

The subject of structures with the exterior wholly of iron will be referred to subsequently in dealing with the question of casemated batteries.

Specimens of open batteries, with the guns *en barbette* may be seen at the Needles' Point, Hatherwood, and Warden Point. These are all high above the sea, and the guns sweep the whole channel of the Needles, from the Point upwards. (Figs. 1, 2, plate xxxiii.)

A specimen of open batteries prepared for iron shields may be seen on either side of Southsea Castle.

#### *Turrets.*

The lateral range obtainable in the barbette system, combined with the protection afforded by the embrasure and iron shield plan, can be obtained by the employment of turrets, which may be employed without reference to the elevation of the battery above the water. The origin of the invention of the turret by Captain Cowper Coles, to whom we are so much indebted for the proposal, was the protection of deck or pivot guns on board ship, by means of shields. To effect this, and at the same time to obtain the greatest lateral sweep of the gun, it was necessary to place both the guns and the men working them, on a turntable, and to attach the shield to the turntable, so that the gun, the gunners, and the protection should revolve together.

The objection to turrets is, that they are very expensive. The cost of a turret for two great guns,—the most economical arrangement of the system,—is however, not less than £15,000, and this irrespective

of the basement of masonry and iron on which it must be mounted, and which must contain magazine accommodation for powder and shells, and space for men. This basement will not cost less than from £5,000 to £10,000, according to whether the turret be alone, or forms part of a work, so that the total cost of a turret complete for two guns, is not less than from £20,000 to £25,000. The question then arises whether that amount of money can be applied to any other kind of work, so as to afford a more powerful fire upon the space to be commanded than can be obtained from two guns in a turret. In many cases it will be found that it *is* so; in other cases, however, like the Spithead forts, where the works are entirely surrounded by water, it will be found that in order to employ the most powerful guns with the greatest effect, it is necessary to employ turrets. (Figs. 1, 2, plate xxxvi.)

#### *Segmental Shield.*

Another plan for mounting guns on turntables, and at the same time protecting them by iron shields, is to give the shield the form of a segment of a circle, in which are two or more ports, according to the extent of lateral range required. A turntable affords the means of turning with facility from port to port, and when fixed with the gun opposite one of the ports, the arrangement for traversing is the same as in an ordinary battery with iron shields. By means of the turntable, the gun may also be rapidly turned round with its muzzle to the rear, and this affords great facility for loading.\*

In cases where great guns are mounted *en barbette*, it will be found advantageous to place them on small turntables, without any shield.

#### *Moncrieff's Carriage.*

I must now notice a very important invention with regard to gun-carriages, which, probably, will very greatly affect the construction of the parapets of open batteries, and which, though not a *substitute* for turrets in all cases, will afford the advantage of lateral range obtainable from turrets and guns on turntables, or *en barbette*, without exposure of the gun to direct fire, except at the time when it is being laid and discharged.

The principle I refer to is that which has lately been so successfully dealt with by Captain Moncrieff, of the Edinburgh Militia Artillery.

Very ingenious suggestions, with a view of attaining the same object, have also lately been made by two Officers of Engineers, Lieutenant Hogg and Lieutenant Lloyd. These two last named Officers proposed to effect the object by different plans, but both by means of two guns, one counterbalancing the other, and to fire alternately.

Captain Moncrieff, in his plan, mounts the gun on a carriage with curved sides, which rock on a level platform; attached to the carriage is a counterpoise weight, rather in excess of the weight of the gun, and which raises the gun,—thus enabling it to get up, like a man, to fire

\* Diagram not engraved.—W.D.J.

over the parapet, whilst it stores up the recoil; when fired, the gun makes as it were, a low curtsey, and retires behind the parapet. (Figs. 4, 5, plate xxxiii.)

There would not be time for me now to enter into the details of the construction of this carriage; and it is unnecessary for me to do so, as Captain Moncrieff has himself fully explained them in two papers which were read by him on the subject in this place.\* The nature of the action will be understood from the model you see here.

The great point of this invention is, that it enables us to protect guns in open batteries by a parapet unweakened by openings, and thus to have the advantage of the great lateral range of barbette batteries, even at a low level above the water, without exposure, except at the moment of firing; it enables us, at the same time, to avoid using iron shields at the embrasures of open batteries, and thus to effect a saving of expense.

Some extra expense may probably be necessary for this gun-carriage as compared with one of the late service-pattern carriages, but I doubt the Moncrieff carriage being dearer than a muzzle-pivoting carriage (which is necessary to afford the smallest opening for an embrasure), and it is with this that its cost should be compared.

But however this may be, the extra cost of the Moncrieff carriages, when applied in any number, cannot, I conceive, be equal to the cost of an iron shield, and it is from this point of view that the question should be regarded. Fortunately we advisedly deferred the provision of iron shields for our works in this country; we are, therefore, in a position, supposing the Moncrieff carriage to be adopted by the artillery authorities, after the full trials which it must necessarily undergo at Shoeburyness, to apply it in all the open batteries in which it has hitherto been proposed to provide iron shields, and that without any expense in the works, except the alteration to the parapets and to the traversing arrangement for the guns.

After witnessing the late experiments with this carriage, I did not hesitate at once to submit proposals for the application of the invention to several of our new works of fortification. Works constructed for carriages of this description will not afford protection against vertical fire, nor are they applicable in cases in which casemated structures are necessary.

#### *Casemated Sea Batteries.*

A work for sea-defence must be casemated when it is necessary to provide by tiers of guns, an amount of fire which cannot be obtained by a lateral extension of the work. A sea-battery should be casemated, when otherwise it would be liable to be plunged into by fire from ships. Casemates are also applied in some cases when it is necessary to secure the battery against the fire of infantry from the rear, and when this cannot be effected by traverses, or when the work is on the side of a hill, or being in front of another battery, must be secured from splinters of rock or shells.

\* Vide Journal of the R. U. S. Institution, vol. x, page 480, and vol. xi, page 241.  
ED.

It will be found in many cases that for sea-batteries, a casemated construction is on the whole not only more efficient, but more economical than a fort with an earthen parapet, supposing the same number of guns to be provided for in each case. The reasons for this are, that whilst in an open earthen battery, the barracks, magazines, and other accessories have to be provided for separately, and the defensive enclosure must be of large area,—and in addition to the battery; —in a casemated work, the battery, barracks, magazines, &c., are provided under the same roof, and the defensive enclosure, which is comparatively small in extent, is formed by the casemated structure itself.

Before describing any particular type of modern construction, different forms of casemate-embrasure and exterior walls that were adopted in sea-defences, prior to the introduction of iron in the casemated batteries may be noticed. Figs. 1, 3, 5, plate xxxiv., show one type adopted in works in England. Fig. 4 is a type of embrasure at Cherbourg.

#### *Introduction of Iron.*

The increase in the power of artillery, however, required a stronger construction than these, and the necessity for employing iron was recognised and put in practice.

#### *First Introduction of Iron.*

The Americans, in their recent casemated forts (which are of two, three, and four tiers in height, with the front walls of granite), introduced pieces of iron 8 inches thick on either side of the throats of the embrasures (Fig. 6, plate xxxiv.). These, however, being small and altogether dependent on the masonry, which at this part of the work is only 5 feet thick, cannot be expected to add much to the amount of protection afforded by the casemate to the gun and its detachment, when subjected to the fire of powerful rifled guns.

The Russians have lately strengthened with iron a few of the embrasures of their casemated forts at Cronstadt (Fig. 2, plate xxxiv.).

The designs prepared in 1861 for the casemates in the English sea-defences (Fig. 3, plate xxxiii., and Figs. 7, 8, 9, 10, plate xxxiv.), provided for greatly increasing the dimensions and strength of the mass of the masonry of the work, and for entirely omitting the masonry round the embrasures, where, owing to the necessity for having sufficient space for the working of the guns, it was weak. Openings were thus left for iron shields, and the construction was arranged so that the iron might be inserted in the openings at any time, when artillery questions relating to the amount of strength necessary to be given to the shields could be positively defined, and when the dimensions and precise position of the embrasures in the shields could be decided in accordance with the newest kind of gun-carriage.

Besides increasing the thickness of the exposed masonry, and substituting iron for granite in the space immediately about the guns, the arches of the casemates have been constructed so as to make the

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Fig. 1.

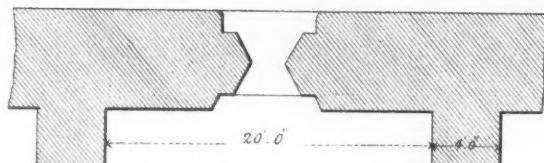


Fig. 2.

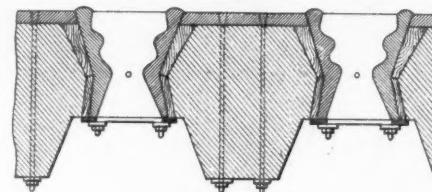


Fig. 3.

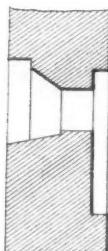


Fig. 4.

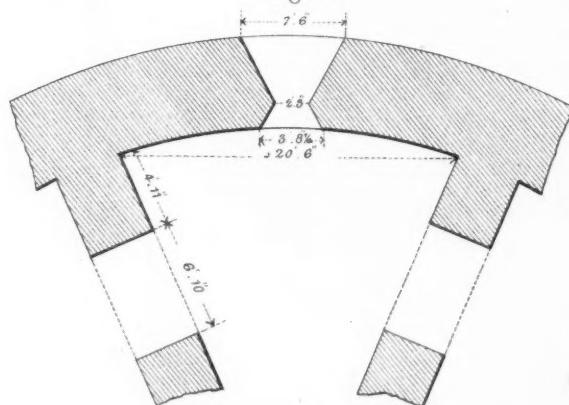
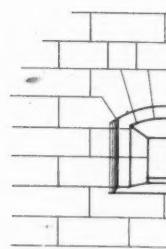


Fig.



ELEVATION OF EMBRAZURE

## SECTION OF EMBRAZURE SHEWN IN FIG. 1.

Fig. 6.

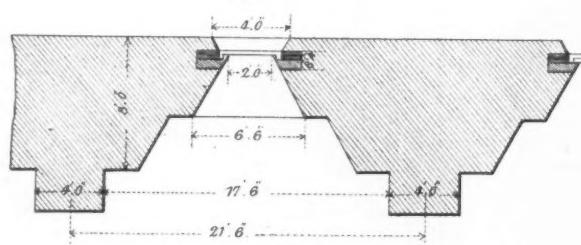
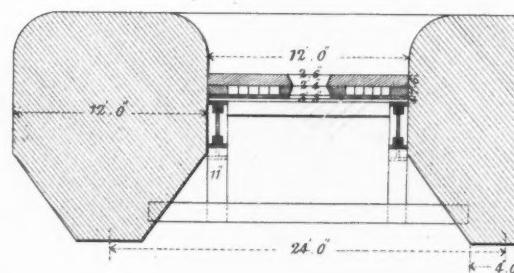


Fig. 7.



SCALE 10 FEET = 1 INCH.



Fig. 8.

## GRANITE-FACED MERLONS WITH IRON SHIELDS

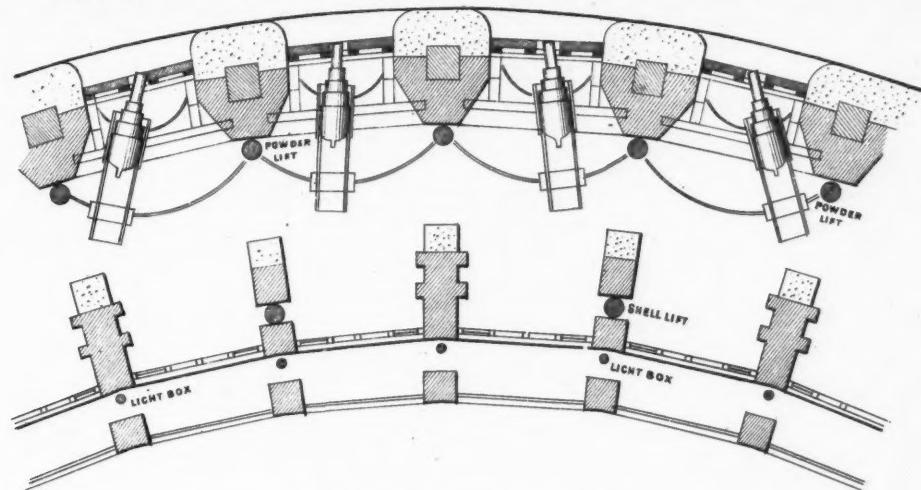
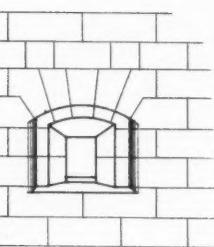


Fig. 5.

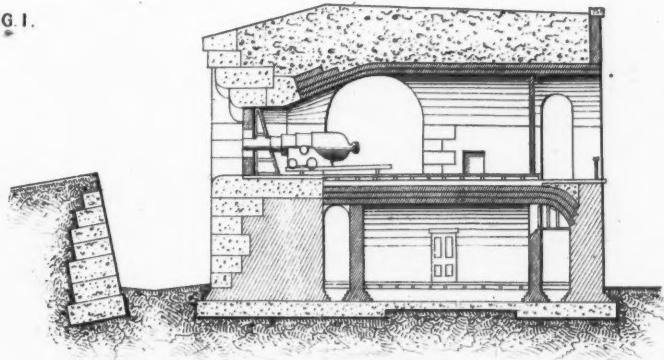


EMBRAZURE SHEWN IN FIG. I.

## HORIZONTAL SECTION THRO' GUN FLOOR.

Fig. 9.

Fig. 10.



SECTION

SCALE 20 FEET = 1 INCH.  
10 5 0 10 20 30 40 50

ELEVATION



whole roof afford support to that part of the masonry above the shields and piers. (See Fig. 9, plate xxxiv.)

Figs. 6, 7, plate xxxiv, shew the mode of construction thus described, compared with the recent American casemated sea-defences.

Figs. 8, 9, 10, plate xxxiv, shew a work of this description for one tier of casemates. This model shows a work of granite with iron shields for two tiers of casemates, similar to that in Fig. 3, plate xxxiii.

These types of work are the most approved for granite casemated batteries combined with iron at the embrasures, and represent the degree in which, with an interval of 24 feet between the guns, the two materials (granite and iron) may be employed.

The introduction of more iron necessitates a reduction in the amount of granite, and the masonry thus becomes so weak that, if the interval between the guns is to be kept at a minimum, it may be better to incur the expense of making the whole exterior wall of iron, and to adopt a different system of construction.

#### *Further application of Iron.*

I will now refer briefly to several proposals which have been made from time to time for the application of iron to fortification. There will not be time to enter technically into this matter; I may, however, be able to convey a general idea of the present position of the question.

The subject divides itself under two heads:—

1. The construction of shields for insertion at the embrasures of casemated forts in which the Moncrieff carriage cannot be used.

2. The construction of the outer walls of forts, whether when made wholly of iron, or of masonry, or other material, and iron, combined.

First as regards shields for embrasures. One of the first ideas of the application of iron to forts is shewn in this diagram. It consists in plating the sides of a masonry embrasure constructed on the old principle. Independently of its not affording much power of resistance, this form is open to the objection that, being funnel shaped, it is calculated to deflect shot, and especially grape and cannister, into the embrasure.

Attention was then directed to obtaining a rectangular iron shield, with a port in it, to occupy the otherwise weak part of the embrasure.

Obviously, if solid plates of the full size of the shield could be made, and could be obtained at reasonable cost, all difficulty of joints, bolts, &c., would be avoided, but the normal dimensions for shields generally, viz., 12 feet wide, by 8 feet high, are greater than those in which any plate of even moderate thickness has yet been manufactured.

Messrs. Brown of Sheffield, acting on a suggestion of Lieut. English, R.E., are about trying to obtain solid plates of these dimensions, but as yet we do not know whether this can be done,\* or, if successful, what the cost will be.

As shields of the dimensions referred to, could not be obtained in one

\* This has since been done, but the cost is not yet known.—W.D.J.

piece, various proposals have been made for constructing them with several pieces of iron, by using bars, plates, planks, rails, &c.

When the application of iron to forts and batteries was taken up some years ago, the object sought was an inexpensive mode of applying it, so as to avoid what was then considered to be the great cost of armour plates.

The first proposal was to use bars, tongued and grooved, and held together by bolts passing through them, or by vertical pieces behind, attached to dovetails on some of the bars.

It was found, however, that the numerous joints and the difficulty of keeping the bars together were against their adoption, unless they were applied in a manner which failed to effect the object for which shields composed of bars were first proposed, viz., economy.

The Russians, however, persevered in the bar system (Figs. 4, 5, plate xxxv), and in one of their most recent constructions I understand they propose horizontal bars 12" thick and 12" deep, backed by vertical bars of like dimensions, and covered on the outside surface with two layers of thin plates.

The result is a shield costing about £3,000 per gun.

The first shield they had made on the bar principle was 12 inches thick, and cost about £2,200 per gun. It is shewn in the diagrams. (Figs. 4, 5, plate xxxv).

It is not so strong as shields of the same thickness which cost this country less than £1,000 a-piece, and are known as the "Gibraltar" shield (Figs. 1, 2, 3, pl. xxxv).

This shield was made on an emergency, and did not pretend to be a perfect one. It is 12' wide by 8' high, is composed of layers of plates supported by horizontal girders and vertical struts, and may be strengthened to any extent by simply adding extra plates to it. One that was tried, was struck by ten rounds from our 9-inch, 10-inch, and the 15-inch American gun, with charges representing a range of 400 yards, and all these shots failed to get through it.

(I may mention, in passing, that the battery of the "Hercules," at present our strongest iron-clad, can be pierced by the 9-inch gun at 1,400 yards).

Several different kinds of shields have been proposed, besides those I have referred to. Shields proposed by Captain (now Lieutenant-Colonel) Inglis, R.E., which consisted of "planks," or narrow plates of iron crossing one another, gave very good results with blunt-headed projectiles; but the numerous joints and the rows of bolt-holes in the centres of the planks, render it undesirable to use planks for outer armour.

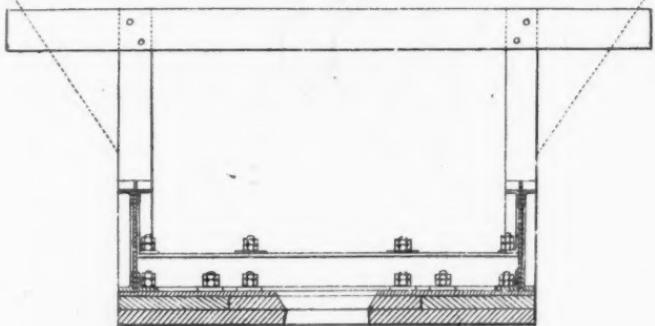
Another shield proposed by Lieutenant-Colonel Inglis consists of layers of plates in a curved form, as shown in this model.

Here are various other forms of shields, proposed by Lieut.-Col. Inglis, the designs of which were prepared to show that in proportion as iron is used in large masses, the cost of the shield is increased.

A shield has been proposed by Messrs. Cammel and Company, of Sheffield, with a view of getting rid of bolts. This is accomplished by fixing together two layers of thick plates by means of dovetail pro-

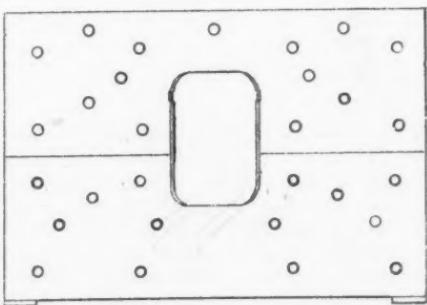


Fig. 1.



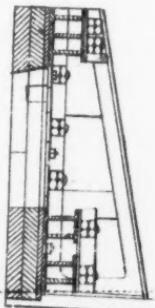
SECTIONAL PLAN THRO' EMBRASURE.

Fig. 2.



FRONT ELEVATION.

Fig. 3.



VERTICAL SECTION THRO' EMBRASURE.

Inches Scale  
1 2 3 4 5 6 7 8

Fig. 4.

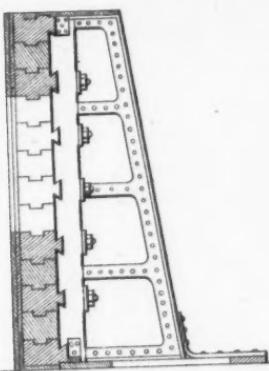
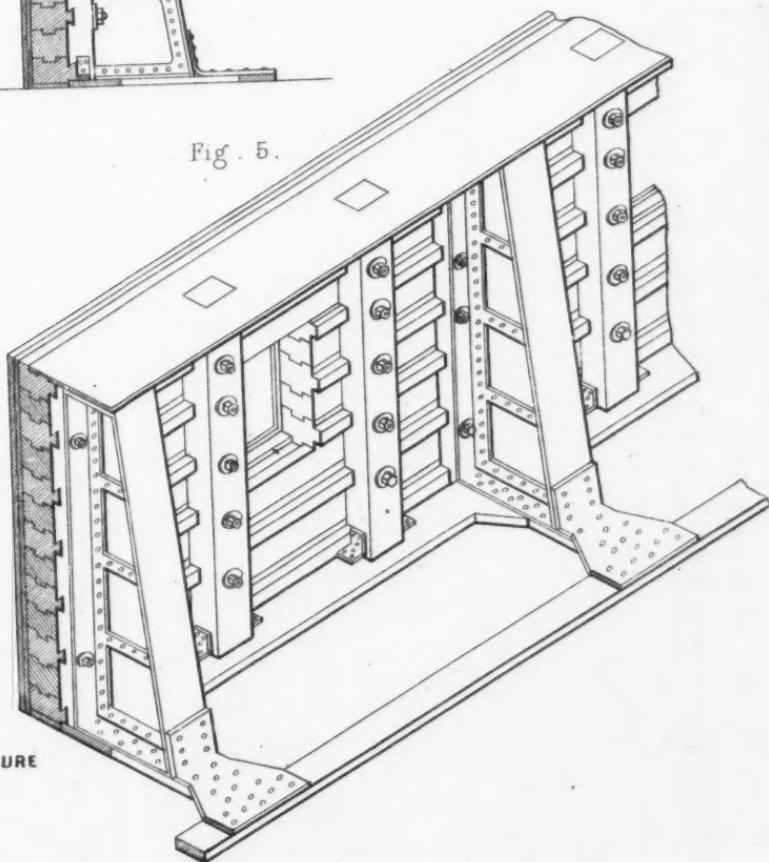


Fig. 5.



THRO' EMBRASURE

Scale 5 Feet to 1 Inch.

6 7 8 9 10 11 12 13 14 15 16 17 18 19 Feet

J. Jobbs



jections, or one layer fitting into corresponding grooves in the other. This shield cannot, however, be strengthened if desired at any time after it has been completed.

The Millwall shield, designed by Mr. Hughes, Manager at the Millwall Iron Works, consists of armour-plates of any required thickness, placed on a backing of large bridge rails, or "hollow-stringers," which are riveted to an inner thin plate; the whole is bolted together with through bolts, and may be strengthened behind by girders. The intervals between the bridge rails in the experimental shield on this principal, which is now at Shoeburyness, and which I expect will give a good resistance, are filled with wood.

A shield designed for forts by Mr. Chalmers, consisted of 4-inch armour-plates resting on thin plates on edge, 8 inches deep, with 2-inch plates behind, further supported by 6 inches of teak, with horizontal iron-stringers, and having an inner skin of 1-inch plate. This was tried at Shoeburyness, and stood a good battering; but the embrasure in this shield only allowed 36° lateral range to the gun behind it. And in all cases of deep shields, where wood backing is introduced, the splay of the port, which should be about 70°, considerably reduces the resistance of a large surface of the shield. This makes it desirable so to construct a shield as to obtain the greatest resistance with little depth.

#### "Laminated" Shields.

Two shields of laminated iron, *i.e.*, a number of thin plates riveted together, were tried by the Iron-plate Committee some years ago at Shoeburyness, but failed. *Thin* plates placed together, offer only a succession of low resisting powers. The case is, however, very different with layers of *thick* armour, crossing each other so as to break joint effectually. These give very good resistances. There has been much misconception on this point. A law was supposed to exist, that the resistance of several plates together was only equal to the sum of the squares of their thicknesses; *i.e.*, the resistance of two 5-inch plates would on this assumption be 50, whilst that of one 10-inch plate would be 100.

The fact, however, is not so.

Experiments have shown that the resistances to penetration of thick solid plates of iron are not so much greater than those of an equal thickness made up of several layers of comparatively thick plates. For instance, the proportions between the resistances of 7 inches of iron when disposed in 1, 2, or 3 layers, are as 61, 57, 52, respectively.

In another experiment, two 5-inch plates gave a resistance equal to a solid 10-inch plate. While yesterday at Shoeburyness a 12-inch Palliser shell penetrated the solid 15-inch plate 12·3 inches, and broke the plate in two, the same shell just penetrated the three thicknesses of 5-inch plates. The Rodman gun, with a charge equal to 100 lbs. of American powder merely makes an indentation a few inches deep both in the solid plate and in the three layers. The result of the firing, by the way, effectually shows the vastly superior powers of our rifle guns over those of the American gun.

The slight superiority of the solid 15-inch plate over the three layers of 5 inches is not compensated for by the difficulties of construction which the use of 15-inch plates would create. In the three layers, the weakness caused by joints can be nearly uniformly distributed over the surface, whereas there are lines of greater weakness at the joints of the 15-inch plates. The method of connecting three layers and of attaching them to the supports by bolts is perfectly successful, but it is doubtful whether 15-inch plates can be properly connected and attached to such supports.

*Experiments now in progress at Shoeburyness, with reference to Outer Walls of Forts.*

I will now make a few remarks with reference to the outer walls of forts, whether when made wholly of iron, or of masonry and iron combined.

We have a specimen of each now under trial at Shoeburyness.

One which represents a section of a design for the Plymouth Breakwater Fort (Figs. 3, 4, pl. xxxvi) has the front wall separate from the front piers, by which the roof is carried. In the other, the front piers of the work are plated.

In the first, two-thirds of the iron wall are composed of 15 inches of iron in 3 plates, each 5 inches thick; about one-third of 20 inches of iron in 4 thicknesses. The iron wall rests against iron uprights, which are fixed into a plate at the bottom, and on the top, rest against the arches of the work, to which they are attached by a plate running round the work, which is oval. The advantage of this kind of structure is, that it can easily be added to by applying an extra plate, and the plates breaking joint, form in this respect a good constructional arrangement. The ports in it are also easily formed by merely cutting pieces out of the plates.

Whilst the experiments now being carried on are incomplete, it would be premature were I to state any decided opinion as to the best form of shield and the best form of iron wall for forts.

I may, however, say, as regards the iron-work of the Plymouth Breakwater Fort, that the late experiments show that, subject to certain modifications which can easily be made, and which had already received consideration, it would have—even if it has not for all practical purposes now—a power of resistance sufficient to defy any possible naval attack.

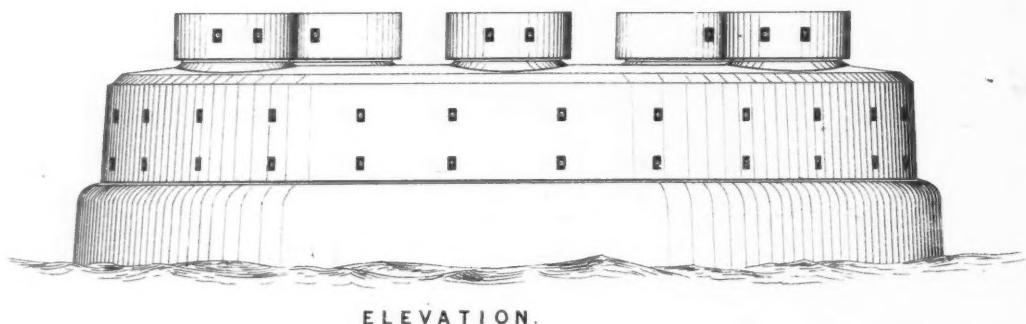
In the other specimen,\* which is just about to undergo trial, but which does not represent any particular fort, the piers of the work are of inexpensive masonry (brickwork in cement) cased with thin iron; the wall between the piers is of Portland cement concrete, also cased with iron, and strengthened by iron cellular compartments.

The armour consists of various combinations, with a view of trying whether solid armour or cellular armour is preferable, and, if the latter, what kind of cellular arrangement is best.

\* The diagram of this specimen has not been engraved.—W.D.J.

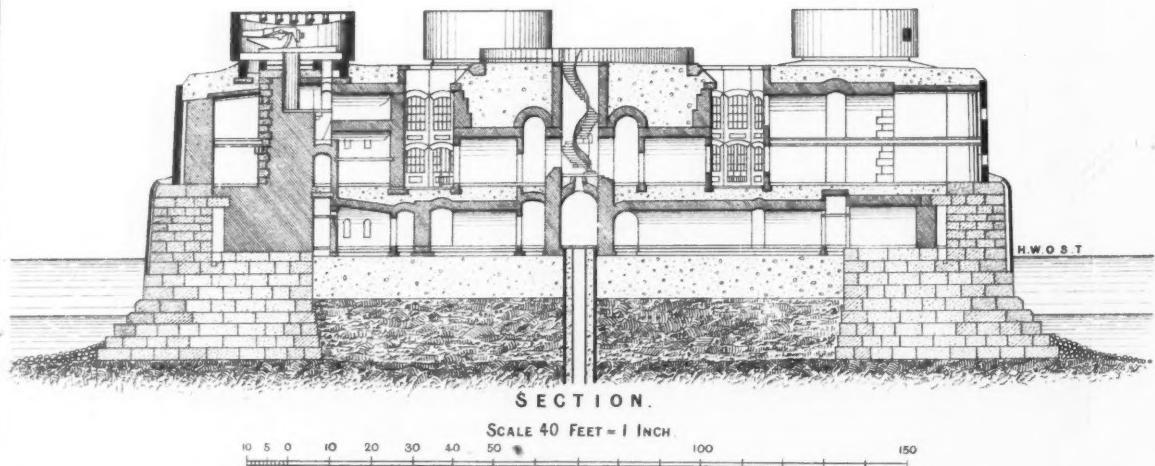
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Fig. 1.



ELEVATION.

Fig. 2.



SECTION.

SCALE 40 FEET = 1 INCH

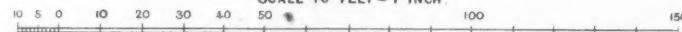


Fig. 3.

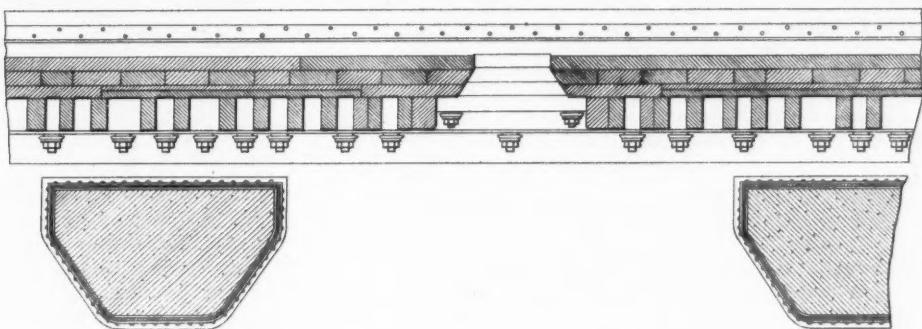
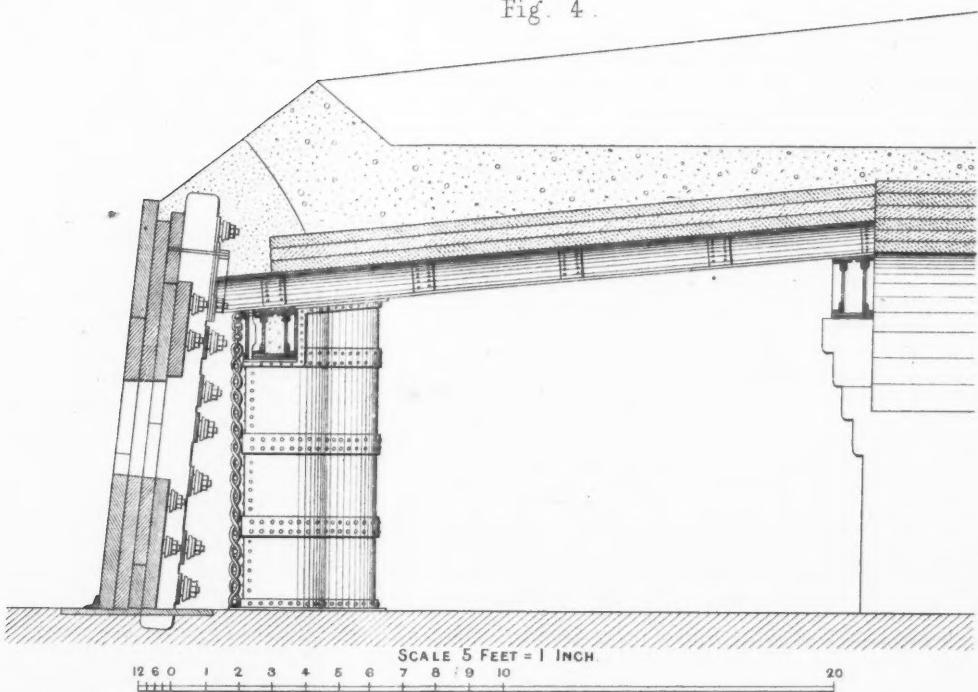


Fig. 4.





The port is strengthened by large vertical iron beams fixed strongly to horizontal iron beams built into the work.

The system I refer to, in which the walls are cased in iron and plated, should not be confounded with stone walls uncased, and only plated on the front. In the latter case, the plates are of little use, as was shown by experiments in America; but when the masonry is confined, and cannot get away on the armour being struck, it adds greatly to the resistance.

Personally, I now incline to the opinion that a backed wall is preferable to an unbacked one, and that, on account of the possibility of wood being deteriorated when the work is required to resist attack, inexpensive masonry or concrete enclosed in iron is preferable. Experiment has, moreover, shown that the more rigid backing affords greater resistance, and though, in the application of this method, unforeseen difficulties might arise from chemical action setting in between the iron and concrete, or from the necessarily small intervals between the girders making their connection imperfect, yet it is not improbable that these difficulties may be overcome. If so, this system may perhaps be economically employed for reducing the thickness of armour in cases where continuous iron cover of great extent is required.

Another advantage attaching to this system would be that any work so constructed might be completed with the exception of the armour (the most expensive part of the work). This might be added at any future time, and at moderately short notice, due provision being made in the erection of the backing for the bolt-holes necessary for the attachment of the armour plate, as has been done in the case of the basements of the Spithead Forts.

The section (Fig. 2, pl. xxxvi) shows the iron-fronted casemates of one of these works, raised upon a thick and massive bed of masonry, in which holes for bolts are left, so that the substructure of the fort may be covered with iron-armour plates, should it ever be deemed necessary to provide such an increase of strength.

The elevation of the same work is shown in the diagram (Fig. 1, plate xxxvi). The battery of this fort consists of 49 guns in two tiers of casemates, wholly iron-plated, with 10 guns in 5 iron turrets on the top. The guns in the casemates will be 400-pounders, and those in the turrets 600-pounders. The weight of metal then that can be delivered in a single round from all the guns would be about 25,600 lbs., while the weight that could be thrown in a single round from all the guns, which are seen in the elevation now before you (Fig. 1, plate xxxvi) would be 14,400 lbs.

The construction of the outer wall of the casemates will be such as the experiments now being conducted at Shoeburyness may show to be necessary.

#### *Degree of Strength required for Outer Walls of Forts.*

Having now referred to several different kinds of structures applicable for coast batteries, I will advert shortly to points bearing on the degree of strength required for the outer walls of forts.

In experiments at Shoeburyness, the fort is treated as a helpless

object, whereas the fact is, that it is able to inflict far greater damage upon its assailant than the latter can inflict upon it; whilst it will hit the assailant nearly every time, the chances of the assailant hitting it more than once on the same spot are small. Further, one shot may send a ship to the bottom, whilst the fire from the ship during action is more or less inaccurate. There is no instance that I know of, of a fort ever having been breached by a ship in a naval action.

In all the cases in which forts were breached during the late civil war in America, the attack was by batteries on land, from which fire can be directed leisurely, and with a precision that is unattainable in a naval attack. In the cases of Fort Sumter, Charleston,—Fort Morgan, Mobile,—Fort Pulaski, Savannah, which are sometimes cited as instances of successful attack on masonry forts, the attacks which were successful were all from land batteries, and the forts were only thin brick structures.

Fort Sumter, at Charleston, was in great part only five feet thick, and nowhere more than eleven feet thick, the most powerful guns in it were two seven-inch pieces, but it beat off a fleet consisting of eight turreted ships (monitors) and one broadside iron-clad of 16 guns, armed with 15-inch and 11-inch American guns. One vessel, the "Keokuk," sank after the action, owing to the effects of the fire from the fort.

Many say that granite casemates with iron embrasures will not stand naval attack; but the experience of men like General Ripley, who commanded in the defence of Charleston against the attack of the Federal iron-clads, and with whom I have had the advantage of conferring on the subject, and the recent examples from the American Civil War, considered in connection with our own experiments, do not, in my judgment, so far as our present information goes, bear out this view. Our granite casemates with iron shields at the embrasures are certainly as capable of resisting the guns of the present day, as Fort Sumter was, the American 15-inch and 11-inch guns of 1863.

General Barnard, one of the ablest Officers of the American Engineers, discussing this question in 1864, writes thus:—

"I readily admit that some very ugly scars may be made upon the surface of our handsome granite walls, but am yet of the opinion that, so long as the embrasure and its surroundings are made secure by iron, nothing an iron-clad can do, armed with the most formidable guns ever yet known to have been put afloat, will seriously impair the offensive powers of the fort, in the limited time the fleet can maintain the contest.

"In this aspect of the case, I do not yet anticipate any extensive substitution of iron for masonry, nor much further use of iron for the protection of masonry than may be necessary to give perfect security to the embrasures. Behind masonry walls, having embrasures thus secured, and under masonry casemates, we can use guns of the most formidable power, such as the 200- and 300-pounder rifled, and the 10-inch and 13-inch smooth-bore, and the importance of the casemate (better made of masonry than any other material) for the pro-

"tection of gun and gunners, has been amply demonstrated by events of this war."

Bearing in mind these views, there are many cases in which granite forts with iron shields at the embrasures will, if powerfully armed, afford the required protection. Where, however, a work is entirely isolated, and from its position specially liable to a concentrated fire, or where the foundations being in deep water are very limited in extent, it is no doubt desirable that the cover in front of the guns should be wholly iron-plated, as, for instance, in the case of the Spithead Forts.

But whatever material is used in the construction of a fort, and whatever may be the amount of iron employed in it, the question of the power of forts and batteries is as much one of the power of the gun,—and, I must add, of the submarine mine protected by the gun,—as of the power of resistance of the structure by which the gun is covered.

Now, I do not think the trials to which the Plymouth Breakwater target has just been subjected, at all represent these circumstances. In these, the power of the guns in the fort was not considered, and the science of submarine mining was ignored.

It is often said, "What is the use of your forts; when they are built, an enemy won't go near them." Probably not. The object of fortifying certain places is to prevent an enemy going near them. The observation, however, is not very consistent with the statement that the enemy will go up within 200 yards of a fort, and smash it.

Every advance that can take place in the power of the gun, will enable it to pierce ships, and so to protect torpedoes, at a greater distance, and is more in favour of the fort than of the ship.

It was not easy to get through the Plymouth target with the most powerful gun at its weakest part, at 200 yards.

On the other hand, as I before stated, the Hercules battery could be silenced with 9-inch guns at 1,400 yards, and at a much greater distance with other guns.

These are reasons which I maintain affect the question of the degree of strength required for the outer walls of forts. Whilst, however, thus stating an individual opinion, the views of the majority appear to be in the direction of absolute invulnerability at any price. If money is no object, difficulty vanishes. It will be satisfactory to know that there is no difficulty in making the Plymouth fort, or any other of our iron forts, of any strength that may be desired.

Meanwhile, I beg permission to say, that having visited most of the works of fortification in America, and having seen several on the continent; being, moreover, aware of what is being done by other nations, I unhesitatingly assert that the forts produced by our engineers are superior to those of any other nation, and that, armed with the powerful guns that are produced by the sister corps—the Royal Artillery—they will give a good account of any enemy by which they may be attacked.

NOTE.—This lecture was delivered just after the experiments at Shoeburyness on the target representing a section of the Plymouth Breakwater Fort.—W.F.D.J.



# The Journal OF THE Royal United Service Institution.

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VOL. XII.

1869.

APPENDIX.

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## PROCEEDINGS OF THE THIRTY-EIGHTH ANNIVERSARY MEETING.

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THE THIRTY-EIGHTH ANNIVERSARY MEETING of the Members was held in the Theatre of the Institution, on Saturday, the 6th March, 1869.

The Right Hon. H. CULLING-EARDLEY CHILDERS, M.P., First Lord of the Admiralty, in the Chair.

- I. The Secretary read the Notice convening the Meeting.
- II. The Minutes of the Proceedings of the Thirty-seventh Anniversary Meeting were read.

III. The Annual Report of the Council was read as follows :

1. THE COUNCIL have the pleasure of submitting the Thirty-eighth Annual Report.

### MEMBERS.

2. One hundred and eighty-eight Members joined the Institution during the year 1868, being an increase of forty-seven on the number of the previous year. The losses by death, however, amounting to one hundred and nine, were greater than for several years past. The number of withdrawals was sixty-eight, and the names of twenty-two have been struck off the list (their subscriptions having been unpaid for three years and upwards). The loss on the year, therefore, amounted to eleven.

A detailed statement of the changes in the list of Members, and a tabular analysis of the past and present state of the Institution, will be found on pages 7 and 8 tx and xi of Appendix).

### FINANCE.

3. The usual Abstract of the Yearly Accounts, as audited on the 9th February, will be found on the following page :—

VOL. XII.

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**GENERAL ABSTRACT OF THE ACCOUNTS OF THE ROYAL UNITED SERVICE INSTITUTION,  
FROM 1<sup>ST</sup> JANUARY TO 31<sup>ST</sup> DECEMBER, 1868.**

London, 9th February, 1869.  
Examined and found correct.

GEO. FELSTEAD, Accountant.

## ESTIMATE OF RECEIPTS AND EXPENDITURE FOR THE YEAR 1869.

EXPENDITURE.	£ s. d.	RECEIPTS.	£ s. d.
Secretary's Salary and Lodging allowance ..	300 0 0	Balance at Bankers 31st Dec., 1868 ..	180 19 10
Librarian's Salary ..	100 0 0	Annual Subscriptions:	
Accountant's ..	100 0 0	At 10s. ..	560 0 0
Clerk's ..	62 0 0	Above ..	1,840 0 0
Servants' Wages ..	400 0 0		2,400 0 0
Ditto Clothing ..	60 0 0	Entrance Fees ..	150 0 0
Insurance ..	20 5 0	Dividends ..	200 0 0
Fuel ..	60 0 0	Sale of Journals ..	70 0 0
Lighting ..	40 0 0	Government Grant ..	600 0 0
Ground Rent ..	205 0 0		
Annuity to John Pitt ..	20 0 0		
Assessed Taxes & Income Tax ..	90 0 0		
Parish and Water Rates ..	100 0 0		
Artificers, Repairs, &c. ..	170 0 0		
Library and Topographical			
Department ..	170 0 0		
Journals ..	850 0 0		
Postage thereof ..	150 0 0		
Museum ..	180 0 0		
Advertisements ..	50 0 0		
Lectures ..	50 0 0		
Printing Annual Report and List of Members ..	90 0 0		
Printing Circulars & Stationery ..	100 0 0		
Postage ..	50 0 0		
Sundries ..	50 0 0		
	3,467 5 0		
Balance ..	133 14 10	Total..	£3,600 19 10
Total..	£3,600 19 10		

## LIFE SUBSCRIPTIONS.

4. The Life Subscriptions received during the year 1868, amounted to £297. Of this sum, £280, together with the balance of £53 6s. 11d. from the previous year, have been duly invested in Three per Cent. Consols.

## CAPITAL ACCOUNT.

5. The funded property of the Institution, on the 1st January, 1868, was £5,732 11s. 2d. £663 17s. 6d. (including Life Subscriptions as above), were invested during the year, making the total on the 1st January, 1869, £6,396 8s. 8d.

LEASE OF THE PREMISES.

6. The Council regret that they are still unable to give the Members any definite information with respect to the tenure of these premises.

They have been in communication with the authorities, and placed before them the claims of the Institution.

The present Chancellor of the Exchequer informed a deputation of the Council, that he could give no decided answer until the future site of the public offices had been determined.

LECTURES AND JOURNAL.

7. The Lectures, and Papers read at the Evening Meetings, during the past Session, were, in the variety and importance of the subjects, fully equal to those of former years.

The Council are gratified to find that the Journal maintains its high reputation both at home and abroad.

They tender their best thanks to those gentlemen who have furnished so much valuable professional information to the Members of the Institution and all persons interested in the progress of Naval and Military Science.

During the year, an Index of the Subjects contained in the first ten Volumes of the Journal has been prepared and issued to the Members. The Council believe that this Index will be found of great value.

LIBRARY.

8. In selecting books for purchase, no new work relating to Naval and Military Science or History has, it is believed, been overlooked.

Among the works that have been presented to the Institution are the following :—

By the AUSTRIAN Government—

Three Volumes of *The War of 1866*, with Plans.

By the BELGIAN Minister-at-War—

*The Triangulation of the Kingdom of Belgium*, Books 1, 2, and 3, containing, among other matter, the Verification of the Base.

By the ITALIAN Minister-at-War—

*The Giornale Militare* for 1867, and the *Annuario Militare* for 1868.

By the RUSSIAN Government—

Eight Numbers of their *Engineering Journal* and Two Numbers of their *Military Journal* for 1867.

By the SWISS Government—

*The Field Exercise for the Troops of the Swiss Confederation*; also a copy of the *Report of the Federal Military Department on its Administration in 1867*.

By Lieut.-Colonel Wright, of the PRUSSIAN Army—

Three Numbers of the *Prussian Account of the Campaign of 1866*.

And by The ROYAL INSTITUTION of Great Britain—

156 Volumes of *Army Lists*, of which twenty were retained to supply deficiencies in the Library, and the remainder presented to the Prince Consort's Library at Aldershot.

The exchange of Journals with Foreign Governments, and with various scientific Societies in this country, has been continued.

The Library now contains 14,100 Volumes.

#### TOPOGRAPHICAL DEPARTMENT.

9. The Bavarian Minister at War has presented 25 Sheets of a Map of the South West of Germany.

The Secretaries of State for War and for India have presented Views of Magdala; Maps of Abyssinia; Photographs of Breech-loaders, of the 7-pounder Mountain Mule-train Guns for Abyssinia, of sundry Targets, and of Moncrieff's Gun-carriage; also Lithographic Plates of the Manufacturing Departments of the Royal Arsenal at Woolwich, &c.

Lord Napier of Magdala has presented fourteen Photographs taken in Abyssinia.

#### MUSEUM.

10. The various additions to the Library and the Museum, both by presentation and purchase, will be found duly recorded in the Appendix to Vol. XII. of the Journal. To the following, however, the Council desire to draw the attention of the Members, viz.:—

1stly. The Pocket-glass of Napoleon I., used by him at the Battle of Waterloo, and given by Sir James Wylie, Bart., (Physician-General to the Emperor Alexander I. of Russia) to Hugh Duke of Northumberland. This glass was presented to the Institution, through Colonel North, M.P., by Eleanor Duchess Dowager of Northumberland,

2ndly. Seven elaborate Models, (horizontal scale  $\frac{1}{25000}$ ) constructed from the Maps of the Prussian Staff, of some of the more remarkable Battle-fields of the Campaign of 1866. Of these Models, six were purchased on behalf of the Institution, by Colonel Walker, Military Attaché, Berlin, of Mons. H. Walger, the eminent modeller of that city. The seventh was presented by Mons. Walger.

The Council are not aware that any other Institution in this country possesses similar Models.

3rdly. The following Breech-loading Rifles, presented by the inventors, viz.:—The Carter and Edwards; the Rutley; the Berdan; and the Wilson. These form valuable additions to the already large collection in the Armoury.

The thanks of the Council have been tendered to the Secretaries of State for War and for India, to the Lords of the Admiralty, and to the various Donors for their respective contributions to the Institution.

### ROBBERY OF COINS.

11. The Council regret to announce that it was discovered in September last, that a number of coins had been stolen from the Library by a Member of the Institution. These coins formed part of a collection bequeathed to the Institution some years since by the late Walter Hawkins, Esq., F.S.A. A considerable number of them, and a portion of the money realised by the sale of the remainder, have been recovered. The culprit, on being brought up for trial at the Middlesex Sessions, pleaded guilty, and was sentenced to five years' penal servitude. A strict investigation into all the circumstances of the case was instituted by the Council. The office of Assistant Secretary and Librarian which became vacant, has been filled up by the provisional appointment of Captain Humphry, late Royal Engineers (Bengal).

### VICE-PATRONS.

12. The Council have had the pleasure of electing his Excellency Lieutenant-General Lord Napier, of Magdala, G.C.B., G.C.S.I., a Vice-Patron of the Institution.

The Principal Secretaries of State, under the present Government, have become *ex officio* Vice-Patrons.

It is with regret that the Council record the death of Field Marshal the Right Hon. Sir Edward Blakeney, G.C.B., G.C.H., late Governor of the Royal Hospital, Chelsea, and a Vice-Patron of this Institution. It would be impossible, within the limits of this Report, to record the varied and brilliant services of this distinguished Officer.

### HONORARY MEMBERS.

13. The Council have elected several Officers of Foreign Services, Honorary Members of the Institution during their stay in this country.

### CORRESPONDING MEMBERS OF COUNCIL.

14. On the 1st January, 1869, there were 279 Corresponding Members of Council, as compared with 213 on the 1st January, 1868.

The Council take the opportunity of the circulation of this Report to thank their Corresponding Members for their services.

### CONCLUSION.

The Council, in conclusion, congratulate the Members of the Institution on the state of its finances and on its general efficiency. They desire, however, to express an earnest hope that the Members will not relax their efforts to obtain for the Institution a more general support from the Officers of the Naval and Military Services.

Captain INGLEFIELD, R.N., F.R.S.—

I beg to propose—

“That the Report now read be adopted and printed for circulation amongst the Members.”

When I came into this room I was asked to move this resolution. I am, therefore, quite unprepared to follow up the motion by making such remarks as I feel many Naval and Military Officers would be able to do. I must, therefore, ask you to excuse me if I say but little more than, that I in common with many Naval Officers, have derived great benefit from this Institution, from being able to consult the records kept in our library, and also from the opportunities which are here afforded to Officers of bringing forward their inventions and improvements, and having them fairly discussed. There are gentlemen here present who will doubtless be able to speak more fully as to the merits of this Institution than I can do. I have only therefore to move “that the Report be adopted and printed for circulation amongst the Members.”

The Motion having been Seconded by Colonel STEPNEY, M.P., was then put from the Chair and carried unanimously.

The names of the eight Members retiring from the Council by rotation, were read as follows:—

W. STIRLING LACON, Esq.	Vice-Admiral G. GOLDSMITH, C.B.
Captain A. C. TUPPER.	Rear-Admiral OMMANNEY, C.B.,
Major-General J. T. BOILEAU, R.E., F.R.S.	F.R.S.
Colonel H. HUME, C.B.	Major-General Sir VINCENT EYRE, K.C.S.I., C.B.
Rear-Admiral A. P. DYER.	

Admiral Sir GEORGE SARTORIUS, K.C.B., Vice-Admiral of the United Kingdom—

I beg to propose “that the thanks of this Meeting be given to the Members of the Council who retire by rotation, and that the following Members be elected to fill the vacancies”:—

W. STIRLING LACON, Esq.	For Re-election.	Captain H. W. TYLER.
Captain A. C. TUPPER.		Lieut.-Colonel The Hon. E. LEGGE,
Rear-Admiral OMMANNEY, C.B., F.R.S.		Coldstream Guards.
Rear-Admiral the Right Hon. Lord FREDERICK H. KEEF.		Rear-Admiral EDWARD S. SOTHEBY, C.B.
	Lieut.-Colonel C. B. EWART, R.E.	

And that the following names be adopted from which to select in the event of vacancies occurring in the Council:—

Major-General J. ST. GEORGE, C.B.	Lieut.-Colonel J. H. LE COUTEUR,
Captain W. HORTON, R.N.	late Coldstream Guards.
Colonel LANE FOX, late Grenadier Guards.	

I have little more to say in proposing this vote of thanks, than that gentlemen have nothing to do but to go round this establishment to see how well deserved are the thanks which we propose to give to the Members who retire, and how thankful we ought to be also to the permanent officers who have so materially contributed to place this excellent and interesting establishment upon its present sound and satisfactory footing. I am glad to say that three of my sons have joined it.

General GASCOIGNE—

I beg to second the resolution. My task is a very easy one, as in the first place

the Vice-Admiral has taken the wind out of my sails if I had anything to say upon the subject. There is no doubt that the resolution will be most acceptable, and I have great pleasure in seconding it.

The Motion was then put from the Chair and carried unanimously.

Captain HORTON, R.N.—

I beg to move the next resolution, which requires no recommendation at my hands. The duties of the Auditors are so important and so well performed that I have nothing to do but to propose the adoption of this resolution, viz.:—

“That the thanks of this Meeting be given to the Auditors for their valuable services, and that the following gentlemen be elected Auditors for the ensuing year:—

THOMAS SMITH, Esq., for Re-election.

Captain J. E. DOLBY.

F. E. DOWNES, Esq.”

The Resolution having been Seconded by Major FARRELL, was put from the Chair and carried unanimously.

Rear-Admiral Sir F. NICOLSON, Bart., C.B.—

The first paragraph of the second section of our Bye-laws provides that certain functionaries shall be elected *without ballot*, but there is no provision made for their election by being balloted for, in the event of their quitting their offices. It is, therefore, proposed to add to the second paragraph of that section the words, “Ex-Governors of Colonies and Dependencies,” who are to be elected by ballot. The paragraph already provides that retired officers shall be so elected, and it must have been a mere omission that Governors of Colonies and Dependencies who are elected without ballot while they hold their offices, should not have been put into that paragraph, in order that they might, after quitting the colonies and coming home, be elected by ballot. We have already had several instances of men of high distinction anxious to become Members. This proposal is to enable them, in a formal and regular manner, to be elected by ballot. The resolution stands thus—

“That in section 2, paragraph 2, of the Bye-laws, the words ‘Ex-Governors of Colonies and Dependencies’ be inserted before the words ‘Retired Officers.’ ”

The Resolution having been Seconded by Lieutenant-Colonel FLETCHER, Scots Fusilier Guards, was put from the Chair and carried unanimously.

The CHAIRMAN then announced that the business of the Meeting was concluded.

The Chair having been taken by Rear-Admiral Sir JOHN HAY, Bart., M.P.,

Admiral Sir HENRY CODRINGTON said—

I have to propose a vote of thanks to the Right Hon. Hugh Childers, for his kindness in taking the Chair on this occasion. We must all feel that it is a great object to us that this Institution should be thoroughly known to those who are at the heads of Departments. There are two reasons for this. In the first place it is a good thing for us, and the more publicity we have the better. That object cannot be better attained than by those who are best acquainted with the Services of the country, coming here and seeing what we are, what our arrangements are, and whether we are really benefiting the Military and Naval services, and are doing our duty to the public as well as to the Members of the Institution. The oftener these gentlemen can come and take part in our proceedings, the better for us. We

are naturally very anxious that they should see everything and learn everything belonging to us. In the second place, we may also say that the advantages are not all one-sided. We feel that as an Institution we are doing them good. We enable them to gain all the information that we can afford them on naval and military subjects. Moreover, as these gentlemen really have not the time to investigate all new inventions, they are enabled to see here the results of many of the new inventions before the public. Here everything is well ventilated, and those who hold high official positions, without having their time too much occupied, can see those inventions for themselves, they can also ascertain what has been the decision of our brother officers on them, and then make up their minds as to whether any particular invention is worth being tried at the public expense or not. We must always remember that we are doing our duty towards the Queen and Government—whatever that Government may be—as well as to the general public. As I have said before, it is not often that gentlemen holding high official positions can find time to leave their duties, which are generally of a very absorbing character, to attend to our proceedings here; we are, therefore, the more grateful when we can secure their services. I am sure that the Meeting will feel with me, that we owe a debt of gratitude to Mr. Childers and other gentlemen holding similar positions for coming amongst us.

General STANHOPE.—

I have a very easy task in seconding the motion which has been made by my gallant friend. We ought indeed to be truly grateful to the right hon. gentleman for taking the Chair on this occasion, and devoting a portion of his valuable time to attending to the interests of this Institution.

The Motion was carried with acclamation.

The Right Hon. HUGH CHILDERS.—

Sir John Hay and Gentlemen, I can assure you, that when I was asked a short time ago if I would take the Chair on this occasion, I felt not only great pleasure but very great honor in that invitation. The connection between the Government and an Institution of this kind, ought to be of the most friendly, and I may say, of the most cordial character; and so far as it in me lies in any way to promote that object, you may on all occasions be quite certain of my best endeavours to do so. Gentlemen, I look upon this Institution—if I may be allowed to say so—as a sort of neutral ground of professional inquiry connected with the two Services. We have political inquiries in the two Houses of Parliament; and we have departmental inquiries at the War Office and at the Admiralty; and you all know that those inquiries and researches cannot be altogether dissociated from questions of pure politics or questions of administration. In this hall and under the auspices of this Society, investigations of the same kind proceed, into which questions of mere party feeling or of administration cannot—and I hope never will—enter in the slightest degree. No one who has had an opportunity, as I have, of perusing the most valuable papers that have been read here, which bear directly upon questions dealt with in Parliament and in the Departments, can fail to be greatly benefited; and I believe that what is done here, influences in a very remarkable degree many things which are done elsewhere. As to the collections of the Society and the objects which those who walk round these rooms observe, there can be no doubt that they are of very great interest. They bring into a focus in a remarkably clear and satisfactory manner, things which no doubt are to be found elsewhere, but scattered over many places, some of them with very inferior arrangements. Therefore, on that ground also, I think this Society ought to receive the best thanks of Her Majesty's Government; and it is satisfactory to me to know that it receives those thanks not only in words, but also in the practical shape which it will be my duty on Monday to recommend to the House of Commons. Gentlemen, I know you will excuse me if I do not say more. I never was present at a meeting where the business was got through in so satisfactory a manner, and I shall not be the person to violate the rule which you seem to have laid down for the conduct of your affairs. Allow me to

say again in conclusion that I thank you very much for the honor which you have done me, and I feel that I shall derive very great benefit from the assistance of your Society.

**General Fox—**

The Right Hon. Gentleman has been kind enough to say that he will assist us in any way he can. May I request him—I am sure we shall all agree in that request—that he will urge upon his colleague, the Right Hon. the Chancellor of the Exchequer, and also upon Mr. Layard to endeavour to procure us a site as soon as possible.

**STATEMENT OF CHANGES AMONG THE MEMBERS SINCE  
1ST JANUARY, 1868.**

	Life.	Annual.	Total.
Number of Members, 31st December, 1867 ..	883	2,940	3,823
"      "      joined during 1868 ..	24	164	188
	<hr/>	<hr/>	<hr/>
	907	3,104	4,011
Changed from Annual to Life	+12	-12	<hr/>
	<hr/>	<hr/>	<hr/>
	919	3,092	<hr/>
Life. Annual.			
Deduct—Deaths during 1868 ..	28	81	*
Withdrawals ..	..	68	
Struck off ..	..	22	
	<hr/>	<hr/>	<hr/>
	28	171	199
Number of Members on 1st January, 1869 ..	<hr/>	<hr/>	<hr/>
	891	2,921	3,812

## TABULAR ANALYSIS OF THE STATE OF THE INSTITUTION,

To 31st of December, 1868.

Year. 1st Jan. to 31st Dec.	Annual Subs. received.	En- trance Fees.	Income (from all sources).*	Life Subs. received.	Amount of Stock.	Invested in the purchase of Books, &c.	No. of Vols. in Library.	No. of Mem- bers on the 31st Dec.	Number of Visitors
	£	£	£	£	£	£			
1831	654	..	654	1,194	..	..	..	1,437	..
1832	1,146	..	1,146	973	..	..	..	2,699	..
1833	1,405	..	1,450	692	..	..	..	3,341	..
1834	1,500	..	1,549	583	1,100	..	..	3,748	13,376
1835	1,480	..	1,574	366	2,430	40	..	4,155	8,537
1836	1,570	..	1,682	330	3,747	45	..	4,069	8,521
1837	1,549	..	1,747	222	4,747	180	..	4,184	10,907
1838	1,462	..	1,634	230	5,500	246	..	4,175	15,788
1839	1,399	..	1,565	168	5,500	292	..	4,186	16,248
1840	1,363	..	1,525	198	5,500	446	5,500	4,257	17,120
1841	1,450	..	1,643	186	6,000	243	5,850	4,243	19,421
1842	1,373	..	1,565	144	6,400	373	6,450	4,127	21,552
1843	1,299	..	1,494	140	6,700	237	7,000	4,078	27,056
1844	1,274	..	1,408	112	3,000	298	7,850	3,968	22,767
1845	1,313	..	1,466	228	1,500	127	8,100	3,988	21,627
1846	1,298	..	1,456	138	1,500	74	8,410	4,031	32,885
1847	1,314	74	1,502	132	1,700	37	..	4,017	38,699
1848	1,175	57	1,375	48	1,700	85	9,641	3,947	37,140
1849	1,176	72	1,375	84	1,150	58	..	3,970	33,333
1850	1,141	106	1,294	198	600	36	..	3,998	33,773
1851	1,136	131	1,292	66	666	34	10,150	3,188	52,173
1852	1,134	133	1,281	114	200	43	10,300	3,078	20,609
1853	1,243	319	1,684	264	528	41	10,420	3,251	25,952
1854	1,200	138	1,368	126	612	95	10,587	3,171	22,661
1855	1,159	107	1,289	120	653	55	10,780	3,131	14,778
1856	1,216	197	1,519	156	761	47	10,832	3,204	16,184
1857	1,258	176	1,937	78	1,038	40	10,960	3,168	12,755
1858	1,318	221	2,102	105	438	31	11,062	3,246	25,747
1859	1,526	195	2,277	512	946	70	11,320	3,344	28,739
1860	1,961	298	3,577	397	2,178	114	11,517	3,518	28,011
1861	2,122	305	2,899	266	2,846	99	11,812	3,689	23,296
1862	2,296	242	3,127	239	3,178	109	12,026	3,797	27,215
1863	2,379	218	3,100	405	3,583	143	12,296	3,847	18,150
1864	2,425	215	3,253	222	4,516	116	12,700	3,902	17,276
1865	2,435	154	3,467	235	4,804	137	13,000	3,895	18,253
1866	2,435	157	3,488	299	5,486	150	13,337	3,891	17,067
1867	2,431	141	3,467	208	5,732	140	13,800	3,823	17,211
1868	2,446	184	3,534	297	6,396	119	14,100	3,812	16,417

\* Including Annual Subscriptions, Entrance Fees, Donations, Legacies, and Interest on Funded Property; and also the Grant from Government, commencing in 1857.

## DONATIONS IN 1868.

Adams, Thomas, Capt. hp. 39th Regt., <i>2l.</i> Greenhill, Barclay, Major Vic. Rifle <i>Volrs. 2l. 2s.</i>	Smith, H. F., Major 1st Midx. Art. <i>Volrs. 3l. 5s.</i> Fane, Charles G., Lieut. R.N., <i>1l.</i>
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**NAMES OF MEMBERS**  
**WHO JOINED THE INSTITUTION BETWEEN THE 29TH JUNE AND**  
**31ST DECEMBER, 1868.**

**LIFE.**

Napier of Magdala, His Excellency  
 Lieut.-Gen., Lord, G.C.B., G.C.S.I.,  
 R.E., *9l.*  
 Barton, Edward, Ensign 27th Regt.  
 Fane, Charles G., Lieut. R.N., *9l.*  
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*Volrs., 9l.*

Bates, C. Ellison, Capt. Bengal Staff  
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 Justice, Philip, Lieut. 108th Regt., *9l.*  
 Lendy, A. F., Capt. Royal South Midx.  
 Mil., *9l.*  
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 R.N., *9l.*

**ANNUAL.**

Fitzgerald, Charles C. P., Lieut. R.N., *1l.*  
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*1l.*  
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 Regt., *1l.*  
 Bale, John Edward, Lieut. 1st W.I.  
 Regt., *1l.*  
 Millington, Walter, Lieut. 3rd Essex  
 Art. Volrs., *1l.*  
 Vereker, Thomas George J., Major late  
 12th Regt., *1l.*  
 Atkinson, Richard, Major 12th Regt., *1l.*  
 Heasty, George B., Capt. Royal Marines  
 L.I., *1l.*  
 Close, Frederick, Capt. Roy. Art., *1l.*  
 Turquand, W. M. Glyn, Capt. Cold.  
 Gds., *1l.*  
 Cassilis, Earl of, Lieut. Cold. Gds., *1l.*  
 Campbell, Hugh, Commr. R.N., *1l.*  
 Guinness, B. Lee Cornet R.H. Gds., *1l.*  
 Colomb, J. R. C., Capt. Royal Marine  
 Art., *1l.*  
 Turnbull, J. R., Major 1st Royal Drags.,  
*1l.*  
 Montgomery, George S., Brig.-Gen.  
 Bombay Army  
 Moray, J. C. D. S., Capt. 28th Bo. N.I.  
 Buller, Charles E., Lieut. Roy. Art.  
 Hatchell, George, Capt. 60th Royal  
 Rifles, *1l.*  
 Beckwith, Henry J., Capt. 53rd Regt.,  
*1l.*

King, Eyare, Lieut. 3rd W.I. Regt.  
 Edgecombe, Piers, Lieut. 3rd W.I. Regt.,  
*1l.*  
 Cundell, J. P., Lieut. Roy. Art., *1l.*  
 Parr, Thomas R., Capt. 1st Somerset  
 Militia, *1l.*  
 Cox, F. K., Capt. late 25th Regt. K.O.  
 Borderers, *1l.*  
 Hall, Basil S. de R., Capt. R.N., *1l.*  
 Walker, Henry C., Lieut. R.N., *1l.*  
 Baker, G. A. A., Capt. 6th Bengal  
 Cavalry, *1l.*  
 Shute, C. C., Colonel 4th Drag. Gds., *1l.*  
 Gully, Philip, Lieut. 22nd Regt., *1l.*  
 Molyneaux, W. C. F., Ensign 22nd  
 Regt., *1l.*  
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 bad Contingent, *1l.*  
 Dick, William, M.D., Dep. Insp.-Gen.  
 of Hospitals, *1l.*  
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 K.O., *1l.*  
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 sars, *1l.*  
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 Royal Bombay Fusiliers, *1l.*  
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 McCrea, F. B., Major 8th or King's, *1l.*  
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- Hogg, Adam, Lieut. 2nd Belooch. Regt., 1*l.*  
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 Dawson, C. S., Major 3rd Buffs, 1*l.*  
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 Warren, William, Lieut. 60th Royal Rifles, 1*l.*  
 Cruikshank, J. D., Lieut. Roy. Eng.  
 Humphrey, Fred., Capt. 2nd Belooch. Regt.  
 Geddes, W. L., Capt. 53rd Regt.  
 O'Hagan, James, Esq., late Department of Works, War Office, 1*l.*  
 Ommanney, Henry Mortlock, Lieut. R.N., 1*l.*  
 L'Aker, John, Capt. 1st London Eng. Volrs.  
 Jessop, Thomas, Lieut. 2nd R.N.B. Drags., 1*l.*  
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 Baines, Frank, Lieut. 18th Hussars  
 Hooper, Fred. Charles, Lieut. 18th Hussars, 1*l.*  
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 Biddulph, G. H. M., Ensign 52nd Regt. L.I.  
 Brownrigg, M. S., Lieut. 52nd Regt. L.I.  
 Barwell, W. B. B., Capt. 52nd Regt. L.I.  
 Jones, George Willoughby, Ensign 97th Regt., 1*l.*  
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 Acland, W. D. A., Lieut. R.N., 1*l.*  
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 Sylvester, J. J., Esq., M.A., F.R.S., Professor of Mathematics, Roy. Academy, Woolwich, 1*l.*  
 Skinner, G. B., Lieut. 15th Regt.  
 Bayly, George Cecil, Lieut. Roy. Art., 1*l.*  
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## ADDITIONS TO THE LIBRARY AND MUSEUM DURING 1868.

### LIBRARY.

#### BOOKS PRESENTED.

- ADDRESS to H.R.H. the Duke of Clarence from several Naval Officers (Original). *General Fox.*
- ADMIRALTY Catalogue of Charts, Plans, Views, and Sailing Directions. 8vo. London, 1868.
- A HISTORY of the Royal Toxophilite Society, Edited by a Toxophilite. 8vo. 1867. *Anonymously.*
- ALMANAC, Nautical, for 1872. 8vo. London, 1868. *Lords of the Admiralty.*
- ANNUARIO Militare del regno d' Italia, for 1868. 8vo. *Italian Minister at War.*
- ANSTRUTHER, P., Major-General. Description of an Instrument to facilitate the drawing of the Trajectory of any Ball, at any Elevation, with any Velocity. Pamph. 4to. 1868. *Captain Fishbourne, R.N., C.B.*
- ARMY List, Official Annual, for 1868-69. *The Secretary of State for War.*
- ARMY Lists, Annual 40 vols. 8vo. Monthly, 98 vols. 16mo. Hart's, 18 vols. 8vo. *Royal Institution.*
- N.B. Of these, only the Monthly Army Lists between the years 1815 and 1834, inclusive, have been retained to complete the series in the Library. The remainder were, with the permission of the Royal Institution, sent to the Prince Consort's Library at Aldershot.
- ARMY. The Queen's Regulations and Orders for the Army, 1868. 8vo. London, 1868. *The Adjutant-General.*
- ARMY Marriages. By Brown Bess. Pamph. 16mo. 1868. *Anonymously.*
- ARTILLERY Reports. Tour of Artillery Officers in Russia. 8vo. London, 1867. Do. do. in Sweden, the Netherlands, and Belgium, in 1864. 8vo. London, 1865. *The Secretary of State for War.*
- ASTRONOMICAL and Magnetical and Meteorological Observations made at the Royal Observatory, Greenwich, in the year 1865. 4to. London, 1867.
- BASHFORTH, Francis, M.D., Professor. Description of a Chronograph adapted for measuring the varying velocity of a body in motion through the air. Pamph. 8vo. 1866. *Lt.-Col. Owen, R.A.*
- BLUE BOOKS : An Abstract of the Returns of Wrecks, Casualties, and Collisions during the year 1866. Folio. *Board of Trade.*
- Correspondence respecting Abyssinia, 1846-68. Folio. 1868. *Secretary of State for India.*
- Abyssinia Expedition. Further Papers connected with. 3 Parts. Folio. 1868. Routes in Abyssinia. 8vo. London, 1867. *Petroleum and Shale Oil. Copy of a Report of the Experiments at Woolwich Arsenal, on the value of Petroleum and Shale Oil as a substitute for Coal. Folio. 1866.*
- Ordnance Maps. Correspondence respecting the Scale for the Ordnance Survey; and upon Contouring and Hill Delineation. Folio. 1854. *Anonymously.*
- Report of the Progress of the

**BLUE BOOKS—continued.**

Ordnance Survey and Topographical  
Depôt for 1858-59-64. 3 vols. Folio.

Ordnance Survey Report for 1855-56.  
Folio. 1857.

Report on the Cadastral Survey.  
Folio. 1861.

Army Estimates of Effective and  
Non-effective Services for 1868-69.  
Folio. February, 1868.

Report of a Special Committee on  
the Gibraltar Shields, together with  
the Minutes of Evidence, &c. Folio.  
1868.

*Secretary of State for War.*

Navy Estimates of Effective and  
Non-effective Services for the year  
1868-69, with Appendix. Folio. 1868.

Greenwich Hospital Estimates,  
Return. Folio. 1867.

Navy Estimates for the year 1867-68.  
Revised Estimate for No. 10 Naval  
Stores. Folio. 1867.

Navy Armour-clad Ships and Bat-  
teries, Return of, since November,  
1855. Folio. 1867.

Navy Designs for Ships. Copy of  
the Circular Letter of the 15th May,  
1867, sent by the Admiralty to several  
Shipbuilding Firms, inviting competi-  
tive plans for building a Turret or a  
Broadside Ship, &c. Folio. 1867.

*The Lords Commissioners of the  
Admiralty.*

Report from the Select Committee  
on Army System of Retirement.  
Folio. 1867.

Copy of Report of Committee on  
Metals to the Lords Commissioners of  
the Admiralty in 1845, on Iron.  
Folio. 1867.

Copy of a Report and Plan of Mr.  
Pennethorne, Surveyor to the Office  
of Woods and Forests, for opening a  
Street between the Thames Embank-  
ment and the Horse Guards, through  
Whitehall Yard and the Garden of  
Fife House. Folio. 1868.

Report of the Progress of the  
Ordnance Survey and Topographical  
Dépôt to 31st December, 1867. Folio.

Report on the present State of Her  
Majesty's Colonial Possessions, 1866.  
Part I, West Indies. Folio. 1868.

Index to the Report from the Select  
Committee on Army System of Retire-  
ment. Folio. 1867.

Statistical Abstract for the United  
Kingdom in each of the last 15 years,

**BLUE BOOKS—continued**

from 1853 to 1867. 15th Number.  
1868.

Reports on the Paris Universal Ex-  
hibition, 1867. Vols. 2 and 6. 8vo.

Return of the Steam Vessels regis-  
tered in the United Kingdom, before  
the 1st January, 1867. Folio. 1867.

Return of the Annual Accounts of  
the several Manufacturing Establish-  
ments for 1866-67. Folio. 1868.

Statement exhibiting the Moral and  
Material Progress and Condition of  
India in 1866-67. Folio. 1868.

Correspondence respecting Hostili-  
ties in the River Plate. Folio. 1868.

Statistical Abstract relating to  
British India, from 1857 to 1866.  
2 numbers, 1865. 8vo. London, 1868.

Army Medical Department. Sta-  
tistical, Sanitary, and Medical Reports.  
Vol. 7, for 1865. 8vo. 1867.

Abstract of Wrecks, Casualties, and  
Collisions on the coasts of the United  
Kingdom for the year 1867, Folio.  
1868.

Abstract of Wrecks, Casualties, and  
Collisions on the shores of the Channel  
Islands, on the shores of Her Majesty's  
Possessions Abroad, and at Sea, during  
1867, with Charts. Folio. 1868.

Report on Railways in India for  
1867-68. By Juland Danvers, Esq.  
Folio. 1868.

Report on Discipline and Manage-  
ment of Military Prisons. By Lieut-  
Colonel Henderson. R.E. Pamph.  
8vo. 1868.

*W. F. Higgins, Esq.*

Bowyer, Sir G., Bart., M.P. Five  
Memoirs on Improvements in Perma-  
nent Fortifications. Pamph. 8vo.  
London.

*The Author.*

British Infantry Drill, as it might  
be. By R. R. Pamph. 8vo. 1868.

*Anonymously.*

CLEEK, H., Colonel, R.A., F.R.S. On  
the Application of Hydraulic Buffers  
to prevent the destructive Effects of  
Railway Collisions. Pamph. 8vo.  
Woolwich, 1868.

Experiments on Frictions. Pamph.  
8vo. Woolwich, 1868.

*The Author.*

COLOMB, J. R. C., Captain, R.M.A. The  
Protection of our Commerce and Dis-  
tribution of our Naval Forces con-  
sidered. Pamph. 8vo. London, 1867.

*The Author.*

XVI PROCEEDINGS OF THE THIRTY-EIGHTH ANNIVERSARY MEETING.

COOKE, Rev. Thomas Fothergill, M.A. Authorship of the Practical Electric Telegraph of Great Britain. 8vo. 1868.

*Lieut.-Colonel Andrews, R.A.*

COMPASS Deviations. Admiralty Manual for ascertaining and applying the Deviations of the Compass caused by the Iron in a Ship. 2nd ed. 8vo. London, 1863.

*The Lords Commissioners of the Admiralty.*

CUNNINGHAM, Alex. W. Notes on the History, Methods, and Technological Importance of Descriptive Geometry. Pamph. 8vo. Edinburgh, 1868.

*The Author.*

DER FELDZUG VON 1866, in Deutschland. 3 Parts. 8vo. Berlin, 1868.

*Lt.-Col Wright, Aide-de-camp to General Von Moltke.*

DETERMINATION of the Positions of Feaghmain and Haverfordwest Longitude Stations of the Great European Arc of Parallel. By Capt. A. R. Clarke, R.E., F.R.S. 4to. London, 1867.

*Secretary of State for War.*

DIRECTORY:

The China Sea Directory. Vol. II. 8vo. London, 1868.

*The Lords Commissioners of the Admiralty.*

DOUGLASS, J. P. A Run through South Wales. Pamph. 8vo. 1868. 2 copies.

*Anonymously.*

DOYLE, Sir F. H. Return of the Guards, and other Poems. 8vo. London, 1866.

*Lieut.-Col. Neville.*

EDWARDS, J. Bevan, Major R. E. An Organization for the Army of England. Pamph. 8vo. London, 1867.

*The Author.*

EVANS, F. J., Staff Captain R.N., F.R.S. On the Amount and Changes of the Polar Magnetism at certain positions in H.M.'s Iron-built and Armour-plated Ship "Northumberland."

*The Author.*

EVANS, Thomas W., M.D. History and Description of an Ambulance Waggon, constructed in accordance with Plans furnished by the Writer. 8vo. Paris, 1868.

Sanitary Institutions during the Austro-Prussian-Italian Conflict. 3rd ed. 8vo. Paris, 1868.

*The Author.*

EXTRACTS from the Reports and Proceedings of the Ordnance Select Committee.

Vol. 5, Parts III and IV, 1867.

" 6, Part I, for 1868.

*Secretary of State for War.*

FINLASON, W. F., Esq., Barrister-at-Law. Justice to a Colonial Governor; or, some Considerations on the case of Mr. Eyre. 8vo. London.

*Captain Godwin.*

GALTON, Francis, Esquire, F.R.S. Meteorographics; or, Methods of Mapping the Weather. Oblong Folio. London, 1863.

*The Author.*

GARDNER, W. B., Major-General, R.A. Hints for the Application of Shrapnel Shell. Pamph. 8vo. Woolwich, 1868. 2 copies.

*Major-General St. George, R.A.*

GRANTHAM, J., C.E. Iron Ship-building, with practical Illustrations. 5th ed. 8vo. London, 1868.

Plates to Ditto. Folio.

*The Author.*

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11th Regt.		Spencer, Hon. J. W. S.	Capt. R.N.	
*Sitwell, H. C.	Capt. 88th Regt.	Spencer, Hon. R. C. H.	Col. (ret.) R.A.	
Sitwell, H. S.	Lieut. R.E.	Spicer, R. W.	Capt. late 16th Lancers	
Skill, H. H.	Lieut. 11th Regt. (1 <i>L</i> )	Spink, John, KH.	Gen. Col. 2nd Queen's Royals (1 <i>L</i> )	
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Skinner, Thos.	Major late Ceylon Rifles	Stacey, W. J. Esq.	Contract Branch War Office (1 <i>L</i> )	
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Sykes, W. H. FRS.	Col. (ret.) Bom. Army MP. (1L)	

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*Trevelyan, H. A. Lt.-Col. 7th Hussars		
Trevelyan, Jas. Harrington Lt.-Col. unatt.		
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Trevor, G. H. Lieut. R.A. Madras		
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Villiers, Hon. G. P. H.	Lieut. Gr. Gds. (1L)	Warde, Edw. Chas. CB.	Maj.-Gen. Commanding Royal Art., Woolwich (1L)	
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Wade, John Peter	Major (ret.) Beng. Army (1L)	Warre, F.	Lieut. late East Kent Militia	
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Form of Request.

*I give and bequeath unto THE ROYAL UNITED SERVICE INSTITUTION, situated in Whitehall Yard, London, the sum of*

*to be applied in and towards carrying on the designs of the said Institution, such Legacy to be paid out of such part of my personal Estate not specifically bequeathed as the law permits to be appropriated by Will to Charitable Purposes.*